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Effects of Different Types of Exergaming on Physiological Responses in Different Age Groups Any Good for Countries with Hot Climates? Literature Review

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Abstract

Sedentary screen time behaviors have increased dramatically in the Gulf region, whereas the prevalence rate of physical inactivity is increasing. Existing evidence show that Active Video Games (AVG) can be a promising tool to create a safe, pleasant environment for performing light to moderate intensity exercise.

Purpose: This review aims to provide an overview of studies that tested the effect of active video gaming (exergaming) on multiple health biomarkers in different age groups for both genders. A secondary objective is to discuss the possibility of introducing active video games as a new physical activity option in different age groups in countries with hot climates.

Method: A systematic review was carried out on studies that tested the physiological responses (mainly energy expenditure) to active video gaming in different age categories for both genders; also, studies that looked at whether this type of activities (exergaming) can induce health benefits and meet the minimal amount of physical activity recommended by the ACSM for both youth, adults and elderly population.

Results: AVGs were found to reduce body weight (BW), increase trunk and spine bone mineral density, and significantly decrease abdominal subcutaneous adiposity, percentage of leg fat and total adiposity. In addition, they were able to elicit light to moderate intensities and to meet the American college of sport medicine's (ACSM) recommendations for maintaining and improving cardiorespiratory fitness (CRF) for both genders in all ages.

Conclusion: AVGs should be considered as a physical activity (PA) option because of its ability to create a safe, pleasant environment for performing light to moderate intensity of exercise. It can also break the perceived barriers to PA, whether it is related to the bad weather, lack of facilities or the shortage of time.

Keywords: sedentary screen time, active video games, energy expenditure

Introduction

Physical inactivity is one of the biggest concerns in the world. Recently, the World Health Organization (WHO) identified physical inactivity as the fourth leading risk among other risk factors for global mortality, where it is the primary cause of the death of two million people each year (6 % of death worldwide) [1]. Sedentary life style is associated with a huge number of comorbidities such as obesity, diabetes, hypertension, osteoporosis and depression [2-4]. According to WHO, two thirds of children around the world are not sufficiently active. Nowadays, 59 to 84 % of people worldwide are living a sedentary life style which will have some serious implications on their health status at some point of their lives. Different reasons have been attributed for the lack of exercise and physical activities per gender, culture, ethnic minorities, religions, socio economic status, knowledge, aptitudes toward exercise and facility availabilities [2,3,5,6].

Physical inactivity has increased progressively in the past few decades, largely due to the increased screen time behaviors in many countries [7]. Screen time refers to time spent browsing the Internet, watching TV or playing traditional video games [8]. Many studies have shown consistent positive relationship between both low PA levels, chronic diseases (diabetes, obesity, hypertension, musculoskeletal fragility, depression) and inactive "screen time" behaviors [9-13]. Statistics show that levels of physical inactivity in the gulf region is among the highest in the world [14]. We shall recall that this part of the world is known by its very hot and humid climate which makes it difficult to exercise outside for a significant period of the year. For example, the vast number of people in Qatar suffering from multiple non-communicable diseases (NCD) is driven partially by the high levels of physical inactivity, which is among the main five contributors to health problems in the world. The most spread diseases in the Gulf region are diabetes (17%) and obesity (59.9% of adolescents; both males and females aged between 14 and 20 years old are obese). In 2003, a study done by Peeters found that diabetes and obesity can reduce someone's life by approximately eight years [15].

Sedentary screen time behaviors have increased dramatically in the Gulf countries due to the dramatic increase in the utilization of the internet, watching TV, playing traditional video games. This means less time is available for individuals to participate in PA because of the prolonged periods of time spent sitting inactively. Rahim, et al. found that the prevalence rate of physical inactivity in Qatar was 46 % [14]. These findings support the importance of minimizing inactive screen time. Although physical activity is a

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major determinant of a good health, important number of Qataris do not exercise.

Mistakenly, there is a common perception that video games are played only by young people. However, a six nation' survey performed by Northwestern university in 2014 found that 17% of individuals aged from 25 to 44 years old or more spend four hours weekly playing video games while individuals who are aged between 18 and 25 or older represent 30 % of the population and they spend up to 5 hours a week gaming [16,17]. The survey took place in the Middle East and the North African (MINA) countries.

The use of active video games to overcome physical inactivity and promote healthy lifestyle is becoming an emerging trend in the physical fitness domain. Active video games, exergames or interactive fitness games are terms used to describe video games that increase the user's energy expenditure by requiring him to apply full body motion to play the game. Various types of AVGs exist such as; interactive aerobic video games, censored pads and motion sensor video cameras.

This review aims to provide an overview of studies that tested the effect of active video gaming (exergaming) on multiple health biomarkers in different age groups for both genders. A secondary objective is to discuss the usefulness of such video games as a physical activity option in countries with difficult climate conditions. Exercising under extreme weather conditions could be impossible and even dangerous in several countries; hence, the point is see if exergaming could be a safer option to exercise indoors.

Method

A systematic review was carried out on studies that tested the physiological responses (mainly energy expenditure) to active video gaming in different age categories for both genders. A particular interest was paid to studies that checked whether exergaming can induce health benefits and meet the minimal recommendation of physical activity by the ACSM for both youth, adults and elderly population.

Inclusion criteria

Studies published between 2000 and 2017 reporting:

• Different health biomarkers [heart rate, oxygen uptake (VO2), metabolic responses, energy expenditure, rating of perceived exertion, step count, body composition] and energy expenditure during exergaming.

• Young, adult and old subjects

• Healthy and/or unhealthy subjects

• Most popular exergaming systems, such as the Konami Dance Dance revolution, Bike games, Wii, Xavix, Sony Eye toy.

• Health biomarkers assessed using valid and reliable physical tests.

Exclusion criteria

Restriction criteria was imposed by limiting the publications that are not published in English, publication date before 2000, studies that looked at the therapeutically use of active video games to treat cognitive and behavioral diseases, and studies that are funded by video gaming companies. However, there was no restriction criteria for the country of study. Original articles, meta-analyses and systematic reviews were used and chosen according to these inclusion and exclusion criteria.

Information Sources and Keywords

The search included the following databases: SPORT Discuss with Full Text, Medline (Medical Literature Analysis and Retrieval System online-national library of medicine), Web of science and Scopus. University and other related organizations websites were also searched for additional resources. Keywords were used separately or combined when required. The following words are related to the physiological responses to exergaming in different age groups with different health status: exergaming, energy expenditure, sedentary screen time, physical activity, physical inactivity, active video gaming, old adults, young, adults, obese, step count, PA recommendations, oxygen consumption, metabolic equivalent and ratings of perceived exertion.

Articles Collection Process

Analyzing and screening the articles was performed manually. The duplicates were excluded and the titles and abstracts were screened. Before the final qualitative synthesis of the studies; the papers retrieved were chosen according to the restriction criteria mentioned above, and their full text were analyzed afterwards. The original articles, systematic reviews and meta-analysis were analyzed separately. A total of 29 studies were identified; eight of them were exuded for not meeting the inclusion criteria. Mainly one investigator conducted the articles screening. Data obtained from the selected experimental studies were summarized into tables for further interpretation.

Results

Overall Results

Twenty-one studies that examined levels of energy expenditure during active video game play were selected. Energy expenditure and heart rate were found to be significantly correlated to active video game play. The vast majority of studies showed that exergaming elicited light to moderate and in some cases vigorous intensities that fall under the recommendations of the ACSM for improving fitness and general heath. Some studies showed the ability of exergaming to alter body composition positively by reducing fat percentage and increasing bone mineral density. It was proposed that playing active video games for longer periods of time can induce even greater benefits. Table 1 summarizes the studies selected for this review.

Game Bike

Game bike is one of the interactive fitness devices that promote exercise through playing video games. The user is required to pedal and to turn the handlebars to steer and control the character's acceleration. Haddock, et al. compared the energy expenditure between both riding a traditional stationary bike

Table 1: Summary of experimental studies that explored the effect of exergaming on health biomarkers using active bike games

Reference	Objective	Sample and design	Dose	Results
Haddock, et al. 2009	To compare the energy expenditure between both riding a traditional stationary bike and the interactive cycling video game.	N=20 aged 7 to 14 years old children (overweight)- Comparison study- Lab based	20 minutes on stationary bike	Interactive cycling video game elicited significantly greater energy expenditure compared to traditional cycling.
Monedero J, et al. 2015	To compare the physiological, perceptual and enjoyment Responses between a single bout of interactive cycling video game and traditional cycling at the same intensity	N= 34, young, men, women- Randomized control study- lab based	30 minutes trial of Game Bike and another 30 minutes trial of traditional cycling at a peak power output of 55%.	Game bike elicited significantly VO2reserve and more enjoyment compared to traditional cycling. the subjects' work intensity was greater during Game Bike trail

and riding an interactive cycling video game (stationary bike to control the video game) in overweight children. The participants' ages ranged from 7 to 14 years old with a BMI classification of "overweight" [18]. Participants' energy expenditure was measured while performing the test on a stationary bike for 20 minutes. For both conditions; energy expenditure and oxygen consumption increased significantly above resting levels. However, interactive cycling video game elicited significantly greater energy expenditure (4.4 ± 102 $Kcal.min^{-1}$) compared to traditional cycling (3.7 ± 1.1 $Kcal.min^{-1}$) ($p < 0.05$). There was no significant difference in the rating of perceived exertion between the two sessions ($p > 0.05$).

Another study in 2015, conducted by Monedero, et al. compared physiological, perceptual and enjoyment responses between a single bout of interactive cycling video game (Game Bike) and traditional cycling at the same intensity. 34 healthy participants performed a 30 minutes trial of Game Bike and another 30 minutes trial of traditional cycling at a peak power output of 55%. Game bike elicited significantly higher energy expenditure (505.8 ± 75.2 vs 487 ± 81.2 $j.Kg.min^{-1}$), and higher percentage of VO_2 reserve (68.2% ± 9.2% vs 64.7 % ± 8.1%) compared to traditional cycling. Taking into consideration the individual's ventilatory threshold; the subjects' work intensity was greater during Game Bike trial (11.86 + 3.08 W) compared to traditional cycling (7.55 + 3.16 W) [19].

Interactive Aerobic Fitness Games

Interactive aerobic fitness games are devices that apply technology to improve and promote cardiovascular activities. The Xavix gaming system and the Nintendo Wii Fit are exercise games that include a variety of activities that allows the user to develop and benefit from different fitness components through different games such as strength, aerobics, balance and flexibility games. A total of 12 published studies that evaluated energy expenditure during interactive fitness game plays were reviewed. All studies examined the acute effect of exergaming on subjects in a single session of interactive fitness games. Data collected from six studies showed a significant increase of energy expenditure above baseline during exergaming sessions (Table 2).

One of these studies tested the effect of 20 weeks of active video gaming using Nintendo Wii on reducing body weight in African-American adolescents. 45 overweight and obese adolescents were randomly assigned to three different groups; competitive (subjects compete against each other) and cooperative (subjects play together to get higher scores) active video game groups and a control group. The exergaming groups especially the cooperative group reduced their weight significantly (1.65 + 4.52 kg) compared to the control group [20].

In a comparison study, Mellecker, et al. compared active and inactive video games in terms of energy expenditure and cardiovascular responses in children. Heart rate values at rest, during inactive video gaming, and during exergaming (Xavix J-Mat and Xavix bowling) were measured in addition to energy expenditure at rest. Results showed that energy expenditure and heart rate during Xavix bowling (102 ± 20 beats/min) and Xavix J-Mat (160 ± 20 beats/min) were significantly higher compared to baseline and inactive computer games [21].

Testing adults this time, Miyachi, et al. conducted a study to determine the effect of Wii Fit Plus and Nintendo Wii Sports on energy expenditure. 12 adults from both genders performed 68 activities that were divided into Wii Fit Plus exercises that involve 63 activities (categorized as aerobics, balance, yoga and resistance) and Wii sport exercises (baseball, golf, bowling, boxing, tennis). 44 of the activities elicited light intensity of exercise, while 22 activities out of 68 (33% of activities) elicited a moderate intensity (3.0 to 6.0 METs) that met the American heart association and American college of sport medicine guidelines [22]. Similar results were found by Guderian, et al. who looked at the effect of Wii Fit video games on the metabolic and cardiovascular responses. Twenty middle aged and older adults (males and females) performed aerobic and balance exercises using Wii Fit video games during a 20-minute testing session. Results showed that Wii fit video games met the ACSM guidelines for sustaining and developing cardiorespiratory fitness in middle aged and elderly people. It was suggested that Wii Fit video games can successfully replace some traditional aerobic activities [23]. Consistent findings were found in a study done by Graves, et al. where they compared the enjoyment and physiological cost of Wii Fit game play with aerobic exercise in adolescents, young adults and older adults. The results showed that exergaming on

Table 2: Summary of experimental studies that explored the effect of exergaming on health biomarkers using interactive aerobic fitness games

Reference	Objective	Sample and design	Dose	Results
Staiano, et al. 2013	To test the effect of 20 weeks of active video gaming using Nintendo Wii on reducing body weight	N=45 overweight and obese African American adolescents – obese and overweight- randomly assigned to 3 different (control, AVG, cooperative AVG) -Randomized control study groups – school based	30 to 60 minutes per school day for 20 weeks	The exergaming groups; especially the cooperative group reduced their weight significantly.
Mellecker, et al. 2008	To compare active and inactive videos games in terms of energy expenditure and cardiovascular responses in children	N= 18 children (11m, 7 f) – ages 6 to 12 years old- Caucasian- Lab based – short term, comparison study	25-minute protocol - 5 min rest - 5 min seated computer bowling- 5 min Xavix bowling- 5 min rest- 5 min Xavix J-Mat	Energy expenditure and heart rate during Xavix bowling and Xavix J-Mat were significantly higher compared to baseline and inactive computer games.
Miyachi, et al. 2010	To determine the effect of Wii Fit Plus and Nintendo Wii Sports on energy expenditure.	N= 12 Japanese adults – ages 25 -44 years old – (7 m ,5 f). Lab based – short term effect study	8 minutes of each of the 68 activities.	22 activities out of 68 (33% of activities) elicited a moderate intensity. The other 44 activities elicited low intensity.
Guderian, et al. 2010	To test the effect of Wii Fit video games on the metabolic and cardiovascular responses.	N=20 middle aged men and women Lab based- short term effect study	20 minutes of Wii Fiit	Wii fit video games met the ACSM guidelines for sustaining and developing cardiorespiratory fitness in middle aged and elderly people
Graves, et al. in 2010	To compare the enjoyment and physiological cost of Wii Fit game play with aerobic exercise in adolescents, young adults and older adults.	N= 42 - both genders -adolescents, young, adults and older adults- lab based Short term effect study	10 minutes of Wii Fiit	exergaming on Wii Fit elicited moderate intensity activity in all 3 populations when compared to traditional games.
Graves, et al. in 2007	To compare the effect of sedentary video games and active video games on energy expenditure on adolescents of both genders	N= 13 Caucasian children - (7 M- 6 F) ages 11 to 17 years old-lab based Short term effect study	15 minutes of Wii Fiit	Energy expenditure was significantly higher during Wii sports game play in boxing bowling and when compared to sedentary video game.
Leatherdale, et al. 2010	To compare the energy expenditure between active and inactive video gaming	N= 51 undergraduate students - lab based Short term effect study	30 minutes of Wii tennis	Active video gaming results in a significantly greater energy expenditure when compared to sedentary video gaming.
Mitre, et al. 2011	To measure energy expenditure during active video gaming and compare it with television watching and inactivate video games.	N=19, 11 m and 8 f children, ages 8-12 years old - 11 lean - 8 overweight or obese- lab based Short term effect study	10 minutes of Wii Fiit	Energy expenditure during exergaming is 50% higher than other sedentary screen time activities.
Mullins, et al. 2012	To test metabolic and cardiovascular responses of young and older adults during active video game play.	N=20, 10 m and 10 f , ages 19 - 64 years old - lab based Short term effect study	4 bouts of 15 minutes using Wii Fiit	Heart rate, oxygen consumption, and energy expenditure were significantly greater than resting levels for all participants.

White, et al. 2010	To measure energy expenditure during active video gaming	N= 26 children – lab based – short term effect	8 minutes for Wii Fiit game	Energy expenditure using AVG increased above resting level.
Worley, et al. 2011	To determine VO_2max % and energy expenditure during exergaming	N=8 girls – lab based – short term effect.	10 minutes for each level of WII Fiit	Aerobic resulted in the highest energy expenditure among all activities and had a similar energy cost of walking at a speed of 5.63 km.h.
Lanningham-Foster, et al. 2009	To determine energy expenditure during rest, standing, sitting watching TV, inactive video games play while seated and exergaming.	N=22 adolescents- ages 10-14 years old and 20 adults -ages 23-45 years old from both genders. Lab based – short term effect.	10 minutes of Wii boxing	Exergaming resulted in a significant increase in energy expenditure above resting levels in both kids and adults.

Wii Fit elicited moderate intensity activity in all three groups [24]. In 2007, Graves et al. compared the effect of sedentary video games (XBOX 360) and active video games (Wii sports) on energy expenditure on adolescents of both genders aged between 13-15 years old. Results showed that energy expenditure was significantly higher during Wii sports game play in boxing (198.1 + 33.9 kl/kg/min), bowling (190.6 + 22.2 kl/kg/min) and tennis (202.5 + 31.5 kl/kg/min) when compared to XBOX 360 which is a sedentary video game (125.5 + 13.7 kl/kg/min) ($p < 0.001$) [25]. A similar study compared the energy expenditure between active and inactive video gaming in 51 undergraduate students using Sense Wear armbands and heart rate monitors. It was concluded that active video gaming results in a significantly greater energy expenditure when compared to sedentary video gaming (192.4 kcal vs 42.6 kcal) with the Sense Wear armbands and (97.4 kcal vs 64.7 kcal) with the heart rate monitors [26]. In 2011, Mitre et al., measured energy expenditure in obese and lean children during active video gaming and compare it with television watching and inactivate video games. Energy expenditure during exergaming (125.3 ± 38.2 kcal/hr) was significantly higher than inactive video gaming (79.4 ±15.7 kcal/hr) and watching TV (79.7± 20.1 kcal/hr) ($p < 0.0001$). It was shown that energy expenditure during exergaming is 50% higher than other sedentary screen time activities [27]. Results that are consistent with the previous study were found by White et al. in 2011 [28]. Targeting healthy younger and older adults this time, the metabolic and cardiovascular responses of participants during active video game play (Wii Fit) were tested and the levels of physical activity during Wii Fit play were compared with the American college of sport medicine recommendations for physical activity. Heart rate, oxygen consumption, and energy expenditure were significantly greater than resting levels for all participants; with the strength and aerobic games inducing the highest elevations. Young and older adult's responses were the same except that in terms of heart rate reserve and ratings of perceived exertion; older adults perceived the activities as more intense. The majority of games elicited light intensity physical activity for young adults, while oxygen consumption and peak heart rate values of older adults for strength (plank, rowing squat, single leg extension) and aerobics (rhythmic boxing, advanced step, super hula hoop) games elicited moderate intensity physical activity recommended by the ACSM [29]. Testing only females, Worley, et al. examined eight young girls using a variety of Wii Fit games to determine VO_2 max percentage and energy expenditure during exergaming. Aerobic games such as the intermediate hula and step games resulted in the highest energy expenditure among all activities and had a similar energy cost of walking at a speed of 5.63 km/h [30]. Lanningham, et al. compared energy expenditure between both children and adults during exergaming and inactive video gaming. 22 healthy adolescents and twenty adults from both genders participated in the study. Indirect calorimeter and accelerometers were used to determine energy expenditure during rest, standing, sitting watching TV, inactive video games play while seated and exergaming using Nintendo Wii aerobic game (boxing). Exergaming resulted in a significant increase in energy expenditure above resting levels in both, children (189 ± 63 kcal/hr, $P < .001$) and adults (148 ± 71 kcal/hr, $P < .001$). As for the movement pattern, it was significantly greater for children (55 ±5 vs 23 ± 2 arbitrary acceleration units) compared to adults [31].

Dance Simulation Games (Table 3)

Dance Dance Revolution (DDR) is one of the most popular dance simulation games. The players should step on arrows laid on a dance platform in response to visual cues displayed on the screen accompanied with music. A total of four published studies that examined the acute effect of dance simulation games on energy expenditure were reviewed. In 2008, one study performed by Sell et al., compared energy expenditure levels between experienced and amateur players during active video gaming. Twelve male college students who are experienced in Dance Dance Revolution (DDR) and seven students who have no experience in DDR were chosen for the study. The participants finished a VO_2max test and a 30-minute session of Dance Dance Revolution game play. Values of oxygen consumption, heart rate, respiratory exchange ratio and step counts were recorded throughout the examination. Unexperienced players showed lower values for all measured variables including levels of energy expenditure, and exercise intensity reached. In addition, they expended more time and steps to burn 150 kcal ($p < .05$) compared to experienced players. The main finding was that experienced players can expand significantly more energy (315.5 kcal vs 144.0 kcal for unexperienced) by working at higher game intensities [32]. Unnithan and colleagues (2006) compared submaximal energy

Table 3: Summary of experimental studies that explored the effect of exergaming on health biomarkers using dance simulation games

Reference	Objective	Sample and design	Dose	Results
Sell, et al. 2008	To compare energy expenditure between experienced and amateur players during active video gaming	N=19 Caucasian male students – ages 17-24 years old -12 experienced in DDR- 7 inexperienced – lab base- acute intervention study.	30 minutes of DDR game play	Experienced players can expand significantly more energy compared to inexperienced players by working at higher game intensities.
Unnithan, et al. 2006	To determine whether the intensities elicited by the simulation video game will meet the ACSM guidelines for improving and preserving aerobic fitness.	N=20, Caucasian children and adolescents, n=12 lean, n= 10 overweight, (16 M and 6 F). – lab base- acute intervention study	12 minutes of DDR game play.	Heart rate intensities elicited during the DDR session was above the minimal intensity recommended by the ACSM to improve aerobic fitness for both overweight and the lean group.
Tan, et al. 2002	To determine whether energy expenditure and intensity levels reached during dance simulation games can meet the ACSM guidelines for developing aerobic fitness.	N= 40 Caucasians – n=21 F and n=19 M - ages 17.5 – lab base- acute intervention study	6 bouts of 10 minutes of DDR	The intensity levels reached during dance simulation test met the minimum amount of intensity recommended by the ACSM.
Fawkner, et al. 2010	To determine the intensity and the energy expended during the activity.	N= 20 Caucasian girls - age 17 lab base- acute intervention study	10 minutes at 3 different levels	Dance simulation games can be used by adolescent girls to meet moderate intensity recommendations of daily exercise.
Staiano, et al. 2017	To test the effect of active video gaming on cardiovascular risk (blood pressure, glucose, insulin, cholesterol, and triglycerides) and body composition	N= 41 obese and overweight teenage girls - ages 14-18 years old. Long term intervention study	36 hours over a period of 3 months.	More than 2600 steps were recorded each session. The abdominal subcutaneous adiposity, percentage of leg fat and total adiposity significantly decreased in the exergaming group. Bone mineral density of the spine and trunk increased in the exergaming group.

expenditure between 10 lean and 10 overweight children and adolescents during Dance Dance Revolution game play and aimed to determine whether the intensities elicited by the simulation video game will meet the ACSM guidelines for improving and preserving aerobic fitness. Cardiorespiratory assessment required finishing a 12-minute session of Dance Dance revolution play and a maximal walking test on the treadmill. When oxygen uptake was normalized to fat free mass; no significant difference was observed in the average energy expenditure between the two groups. The average absolute oxygen uptake of the overweight group (917.1 ± 287.1 ml/min -1) was significantly higher than the lean group (590.6 ± 147.9 ml/min^{-1}) during the Dance Dance Revolution session. Heart rate intensities elicited during the DDR session was above the minimal intensity recommended by the ACSM to improve aerobic fitness for both overweight (64.83 % ± 7.14) and the lean group (64.51 % ± 7.71) [33]. Similarly, Tan, et al. conducted a study to determine whether energy expenditure and intensity levels reached during dance simulation games can meet the ACSM guidelines for developing aerobic fitness. 19 females and 21 males aged 17.5 ± 0.7 years old were chosen to participate in the study. The subjects' heart rate and VO_2 max were assessed during a maximal treadmill test and during a session of Dance Dance Revolution. Data were collected after the test showed that energy expenditure during Dance Dance Revolution was estimated by 480 , average VO_2 of 24.6 ml * kg^{-1}-min^{-1} and an average heart rate of 137 bpm for both males and females. The intensity levels reached during dance simulation test met the minimum amount of intensity recommended by the ACSM. Tan, et al. concluded that in order for players to develop their cardiorespiratory fitness and manage their body weight; they are required to play for longer periods [34]. Testing only girls, Fawkner and colleagues tested 20 adolescent girls during dance simulation game to determine the intensity and the energy expended during the activity. Resting heart rate and VO2 were assessed at rest (seated) and during three levels of increasing difficulty play; each one lasted for 10 minutes; total of 30 minutes. Energy expenditure increased proportionally as the level of difficulty increased from stage 1 (3.63 ± 0.58 kcal.min^{-1}) to stage 2 (3.65 ± 0.54 kcal.min^{-1}) to stage 3 (4.14 ± 0.71 kcal.min^{-1}). All stages' mean activity during dance simulation game elicited moderate intensity (> 3 METS). The main finding of the study was that dance simulation games can be used by adolescent girls to meet moderate intensity recommendations of daily exercise [35]. Supporting the previous 2 studies, Staiano, et al. conducted a study to test the effect of active video gaming on cardiovascular risk (blood pressure, glucose, insulin, cholesterol, and triglycerides) and body composition on teenage girls. Forty-one girls aged between 14 and 18 who are suffering from either overweight or

obesity were divided into a control group (no intervention) and an active video gaming group that required the subjects to play 36 hours over a period of 3 months. More than 2600 steps were recorded each session. The abdominal subcutaneous adiposity, percentage of leg fat and total adiposity significantly decreased in the exergaming group. Bone mineral density of the spine and trunk increased in the exergaming group [36].

Sony Eye Toy (Table 4)

Just like the webcam; the Eye Toy is a digital camera. However, unlike a regular webcam, the Eye Toy processes the photos captured by using computer vision and gesture recognition allowing the users to use movement to interact with the game. One study investigated levels of physical activity in children during active video using the Eye Toy. Twenty children aged 12 ± years old were randomly assigned to either the intervention group (Eye Toy gaming) or the control group. Accelerometers and PA questionnaire for children were used throughout the twelve-week intervention to determine how physical activity was affected. Time spent using sedentary video game and exergaming using the Eye Toy was estimated by using an activity log. Accelerometer showed that energy expenditure expended during Sony Eye Toy exergaming group was higher at 6th week (194 counts/min) and at the 12th week (48 counts/min). Taking into consideration that 194 counts per minute is considered as light intensity PA; authors suggested that using the motion capture technology games such as the Sony Eye Toy can promote and develop levels of PA in kids [37]. Another study used motion capture based gaming device to examine the influence of exergaming on levels of physical activity and weight reduction in 75 children (41 girls and 34 boys) who are involved in a credible program for weight management. Overweight and obese children aged 10 ± 1.7 were chosen from a pediatric program for weight loss. A weight management program called "JOIN for ME" was assigned to both the intervention and the control groups. However, active video gaming was assigned only to the intervention group. There was no change or a decrease in the moderate to vigorous and vigorous physical activity in the control group (program only) (mean net difference, 8.0 ± 3.8 min/day; p=.04 and 3.1 ± 1.3 min/day; p=.02). Whereas moderate to vigorous and vigorous physical activity levels significantly increased in the program and exergaming group in the 16th week (mean SD. 7.4 ± 2.7 min/day and 2.8 ± 0.9 min/day). At week 16, BMI z scores and overweight percentage significantly decreased in both groups. Nevertheless, higher reductions were observed in the exergaming and program group in the BMI z scores and overweight percentage (mean SD, -0.25 ± 0.03 vs -011 ± 0.03; $p < .001$) and (-10.9% ± 1.6% vs -5.5% ± 1.5%) respectively [38].

Table 4: Summary of experimental studies that explored the effect of exergaming on health biomarkers using Sony Eye toy AVG

Reference	Objective	Sample and design	Dose	Results
Ni, et al. 2007	To investigate levels of physical activity in children during active video using the Eye Toy.	N= 20 Caucasian children -ages 12 years old – (12 M , 8 F) – n=10 intervention – n= 10 control – home based – randomized control study.	12 week of Sony eye toy game play	energy expenditure expended during Sony Eye Toy exergaming group was higher at 6th week (194 counts/min) and at the 12th week (48 counts/min).
Trost, et al. 2014	To examine the influence of exergaming on levels of physical activity and weight reduction	N= 75 overweight and obese children- n= 41 F -n= 34 M - long term intervention study.	16 weeks	BMI z scores and overweight % significantly decreased in both groups. Nevertheless, higher reductions were observed in the exergaming and program group in the BMI z scores and overweight %

Discussion

Since active video games are gaining popularity among different age groups, youngsters, adults and even elderly populations, it is important to review what studies have found in relation to physical activities and active video gaming. Therefore, this review aimed to provide evidences from studies that tested the effect of active video gaming (exergaming) on different health biomarkers in different age categories for both genders. As also mentioned above, this review aims to discuss the possibility of introducing active video games as a new physical activity option in different age groups in countries with hot climates.

All evidence from the 21 reviewed studies showed that exergaming can elicit intensities that meet light and moderate ACSM recommendations as well as minimizing time spent inactively. All studies that evaluated the physiological responses such as heart rate, metabolic equivalents, cardiorespiratory fitness, VO_2 during exergaming showed that intensities reached during active video gaming didn't only meet ACSM recommendations for preserving and improving aerobic fitness, but also it induced several important health outcomes such as significantly reducing body weight, increasing trunk and spine bone mineral density, significantly decreasing abdominal subcutaneous adiposity, and decreasing percentage of leg fat and total adiposity in overweight and obese subjects. Although most of these studies investigated the acute effects of exergaming, they showed that these active gaming is capable of significantly increasing energy expenditure above resting levels and elicit light to moderate-vigorous exercise intensities in a short period of time. Therefore, taking into consideration what Weaver et al. found, playing in the traditional environment (home) can result in even higher energy expenditure when compared to lab based testing [39].

We shall remind that exergame that induced the highest energy cost was the Dance Dance revolution by Konami where there was an increase of 300% in energy expenditure above

baseline [35]. Followed by a 230% increase in energy expenditure induced by Nintendo Wii play and a 108% increase induced by the Sony Eye Toy [25, 40].

Usefulness to Countries with Hot Climates

There is a paucity of literature sources regarding the use of exergaming in countries with hot climates, however, amongst the ones we reviewed it has been shown that significant number of children and adults spend 4 to 5 hours playing video games weekly. This amount meets the weekly physical activity recommendations indeed. The question would be: could this be a good alternative to remedy to the lack of physical activities in these countries? We shall remind that the prevalence rate of physical inactivity in Qatar for instance is 46% which is among the highest in the world and the region [15]. Sedentary life style has been a major concern for authorities and public health services in the gulf region, as physical inactivity is directly linked to major health complications such as diabetes, obesity, hypertension, musculoskeletal fragility and depression [13-14]. As these numbers keep on rising among young people and traditional strategies failed to overcome these health issues, a new strategy should be introduced to overcome physical inactivity since previous methods do not seem to be so effective. Active video games can be used in schools during physical education classes when the weather is so difficult. Children could exercise within a safe environment and without any risk of excessive sun exposure. Exergaming could also be used during school breaks which might increase the interest of children and adolescents and attract them to a more regular exercise and ultimately will help them increasing their daily energy expenditure. It is likely that active video gaming would better appeal to physically inactive children and adults who might suffer from overweight or obesity over traditional physical activities [41]. Exergames are indeed less intimidating for those who suffer from low self-image and lack of self-esteem. In addition, it has been argued that traditional physical education classes might not fulfill the interest and connect properly with today's young generation of students. These later might be more interested and motivated to take part in the learning process with activities that are technologically driven, involve communication and have better rewarding system, such as active video games compared to traditional physical education classes [42].

Some studies in the United States that examined the effectiveness of active video games in schools' settings found that exergaming can be a great tool that can be used to meet the guidelines of daily physical activity during physical education classes. A long-term intervention study aimed to determine whether 40 minutes of dance exergame per week can meet the intensity of moderate to vigorous physical activity. Fifty-eight middle school youth aged 13.7 ± 0.6 years old were divided into a control group and an intervention group (Generation Fit) in a study that lasted 20 weeks. The intervention group was assigned to play an active video game from the start of session one that is composed of 10 weeks whereas the control group joined in the second session (week 10 to week 20). From the first to the second session, average exergaming time increased from 49 to 54 minutes per week. Data collected from accelerometers showed that half of the time spent in exergaming was spent at a moderate to vigorous intensity levels. In addition, reductions in BMI percentages were higher in the exergaming group compared to the control group (5.6 % vs 0.2 respectively) [43]. Supporting these findings, another study examined how can active video gaming affect levels of physical activity in four sedentary children during physical education class. Four 5th graders aged nine years old were chosen based on their low physical activity during classes and their low fitness scores. Results showed that the amount of time spent being physically active was higher during active video gaming compared to traditional physical education class. Moreover, it was socially accepted to use active video gaming for both the teacher and the students. These two studies suggest that active video gaming is a promising method to overcome high levels of physical inactivity among sedentary and obese children [44].

Several schools in the United States have indeed started putting this method into action. For example, Dance revolution have been implemented in physical education programs in 20 public schools in west Virginia since 2006, and it showed promising results; where some of the students showed weight lost between 2.5 to 5 kg. This number increased to 765 schools nowadays [45]. Fourteen different regions in California have been using the Dance revolution classroom edition game in their schools thanks to a partnership between the creator of the game Konami and California endowment.

Limitations of Exergaming

Although current findings from different studies have supported the positive impact that active video gaming has on promoting physical activity and its ability to increase energy expenditure above resting levels and establish moderate to vigorous intensities researchers still question the ability of exergaming to replace vigorous physical activity [18-25-46]. Despite the numerous benefits of active video games; they still have some limitations. One of the limitations is the inadequate time spent working at a moderate intensity due to the multiple rest periods following each intense but short bursts of energy. These periods of rest might have artificially increased the total play duration. Daley showed that exergaming at home usually lasts between 1 to 2 hours whereas exercise sessions (exergaming) lasted 10 to 30 minutes in the vast majority of the studies reviewed [41]. Therefore, a mutual limitation between the majority of studies reviewed is the lack of compatibility between the testing procedures and the typical exergaming conditions at home in terms of the duration of play and therefore the amount of energy expended.

Furthermore, different exergames yield different rates of energy expenditure. Even within the same exergame device system, energy cost can differ between a game and another [41-47]. Another limitation is the significant lower energy expended during exergames when compared to real sports. However, one study showed that interactive cycling video game elicited significantly greater energy expenditure (4.4 ± 1.02 $Kcal.min^{-1}$) compared to traditional cycling (3.7 ± 1.1 $Kcal.min^{-1}$) ($p < 0.05$) [18].

From another front, one of the biggest problems that can face the strategy of implementing exergames in schools is the challenge of maintaining the interest and a long-term adherence of the users. It was reported in some studies that because of the lack of progression and the repetitive nature of some active video games; children tend to lose their interest and motivation to participate in active video games [47].

Finally, some of the exergames that rely on motion capturing and displaying the user's oneself on the screen was found to be positively related to reducing self-efficacy and enjoyment of exercise in those who have a negative body image about themselves [44]. Motivational strategies within the exergame itself that aims to maintain the interest and the attraction of children towards physical activity should be developed and improved to ensure a long-term adherence. The five-dimension model that measures the situational interest can be used in the future to create games that can maintain the interest of the children through fulfilling and satisfying the five situational interest sources. If the exergame is capable of providing immediate enjoyment, develop innovation and interest, exploration, attracts attention and it's challenging, children and adults will be more interested [48].

Conclusion

In conclusion, existing evidence shows that active video games can be a promising tool to create a safe, pleasant environment for performing light to moderate intensity of exercise. Exergames were found to reduce body weight, increase trunk and spine bone mineral density, and significantly decrease abdominal subcutaneous adiposity, percentage of leg fat percentage and total adiposity. The main result of this review is the capability of active video gaming to elicit light to moderate intensities and to meet the ACSM recommendations for maintaining and improving cardiorespiratory fitness. Further studies are needed to determine the ability of exergames to motivate people to maintain high levels of adherence in their fight against physical inactivity. The accessibility, the attractiveness and the high enjoyment level provided by exergames as a physical activity option in the home setting can break many perceived barriers for physical activity; whether it is the bad weather or lack of facilities or the lack of time to exercise.

In closing sedentary lifestyle remains a serious health problem that affects different age categories of people. Different approaches should be used to promote long term participation in physical activity, this can be done by implementing either designed interventions to fix the problem directly on the field or by providing educational programs to educate people about the guidelines and the benefits of exercise.

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