



The futuristic model for physical activity and exercise: active video games

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Authors' Contribution: A – Study Design, B – Data Collection, C – Statistical Analysis, D – Manuscript Preparation, E – Funds Collection

Abstract

Physical inactivity is one of the main causes of noncommunicable diseases worldwide. In addition, obesity worldwide is increasing day by day due to insufficient energy expenditure, which is the result of physical inactivity. This review aimed to examine the physiological effects of active video games (AVGs) systems and tried to define whether the AVGs could be suggested as an alternative exercise model considering the American College of Sports Medicine (ACSM) criteria. This review was based on the physiological responses of the different AVGs that were discussed in previous studies. It was revealed that AVGs significantly increased the energy expenditure and metabolic equivalent according to resting state. The majority of AVGs were found to achieve physical activity levels of moderate intensity which meet ACSM criteria for health and fitness (3-6 MET). Especially, AVGs can be considered as an alternative exercise model that is integrated with fun and technology in everyday use of individuals, reducing obesity prevalence and improving physical activity level with the ever-evolving modern and sophisticated AVGs systems. AVGs can actually be considered among the exercise models for the future, with the increasing use of active video game systems around the world.

Keywords: active video games, exer-game, physical activity, energy expenditure, heart rate.

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Received: 07.11.2017; Accepted: 26.01.2018; Published online: 21.03.2018

Cite this article as: Aygun C, Cakır-Atabek H. The futuristic model for physical activity and exercise: active video games. *Physical Activity Review* 2018; 6: 45-53. doi: 10.16926/par.2018.06.07

INTRODUCTION

Based on the advancements in technology, energy consumption in everyday life because of dominating sedentary lifestyle is decreasing more and more every day. Advancement in technology has altered people's lifestyles and provided great physical convenience. However, the downside to this situation, people have moved away from a physically active life. This has caused individuals to have weight control troubles and increment in health problems due to an inactive lifestyle. One of the most important reasons of an inactive life is that people prefer to spend more time at home when they are not working and to spend time entertaining themselves with technological tools such as mobile phones, tablets, computers, televisions and video game consoles [1]. Additionally, all the mentioned technological tools are increasingly taking more place in human life which also cause an inactive life [2].

Physical Inactivity

The World Health Organization (WHO) has reported that physical inactivity is the fourth most important factor for global mortality (it has been identified to cause 6% of global mortality rate) [3]. It is also known to cause the risk factors of several chronic diseases such as diabetes, cardiovascular diseases and cancer [4]. In addition to this, it is reported that physical inactivity causes more than 1.9 million premature deaths across the globe every year [5]. Lack of physical activity leads to not only physical health problems but also has a bad impact on mental health [6]. Inactive lifestyle is listed at the top of the deaths caused by non-infectious diseases worldwide and they cause the death of approximately 3.2 million people every year. It is indicated that 31% of all individuals aged 15 and above across the globe are not active enough [7]. According to the "Chronic Diseases Risk Factors Research" conducted in 2011, it has been determined that 77% of men and 87% of women in Turkey do not exercise sufficiently [8]. These data and rate show that the inactive lifestyle is also a serious problem for Turkey as it is the case in other countries. Along with this, studies have demonstrated that even short-term physical inactivity can cause metabolic and vascular diseases [9]. Amati et al. [10] highlight that insulin resistance does not stem from an old age, but rather obesity and physical inactivity.

In addition to the health dimension, economic dimension of physical activity is considerably important. Physical inactivity has a broad economic impact. This impact is due to loss of production and income caused by diseases. It is estimated that the healthcare expenses related to physical inactivity in the United States of America was equal to USD 5.7 billion in the 1990s, whereas in 2000s, it is estimated that the healthcare costs arising from being overweight and obese reached USD 117 billion. Until the 2005, it has been estimated that the total costs caused by physical inactivity exceeded USD 250 billion [11]. The healthcare costs for the patients diagnosed with Type 2 diabetes in Turkey are estimated to be between TRY 11.4 and 12.9 billion. The amounts spent for cardiovascular diseases have the largest share with a ratio between 24.3% and 32.6% in proportion to total healthcare costs [12]. The diseases that may arise due to lack of physical activity are spreading across the globe in the same way as epidemics. However unlike epidemics, we can overcome this situation by increasing the amount of physical activity in our daily lifestyle [13].

Benefits of Physical Activity

Physical activity is defined as increased requirement of energy consumption for performing specific body movement in comparison to sedentary mode. The higher physical activity level causes the lower risk of having diseases [14]. Hence, in nowadays the physical activity is one of the most important factor to protect health from diseases, such as obesity, diabetes, and cardiovascular diseases [15].

It is recommended for an adult to exercise at moderate intensity for 30 minutes every day and five days a week. Such an exercise program can result in energy consumption approximately between 5-7 Metabolic equivalent (MET) [15]. People must change their daily lifestyle and exercise in order to be healthy and to prevent any diseases that might be caused by an inactive lifestyle. Even though the use of technology causes an inactive lifestyle and a number of health problems along with it,

technology can also contribute to a healthy lifestyle owing to the opportunities that it provides to individuals. When considered from this perspective, people can adopt a more active lifestyle just by playing active video games (AVGs). Several studies have examined whether AVGs increase in the physical activity level among certain age groups and tested whether these results fulfill the healthy lifestyle criteria among the American College of Sports Medicine (ACSM) criteria. Worldwide, individuals have tended more and more towards inactive life and the spend time spend on the screen increases day by day. Whether playing AVGs and doing physical activity alongside with it, instead of spending time without any exercise in front of a screen can contribute to the healthy lifestyle and this issue has attracted significant interest over the recent years.

Active Video Games

With the increase in the use of game consoles, it is observed that people prefer to spend time entertaining themselves by playing video games. It has been reported that video games are played in 67% of the houses in the U.S. and individuals play games for 8 hours in a week on average [16]. Video games can be examined in two categories as sedentary (passive) video games and active video games:

- A- Sedentary games are those that are played by sitting in front of a screen and require movement only by the fingers in the body.
- B- On the other hand, active video games (AVGs) are those that are played via devices with motion sensor cameras in their system, and where players have to make the bodily movements required by the game in front of the screen.

Nintendo Wii, Sony Play Station - Move and Microsoft Xbox Kinect AVGs systems are the most well-known and preferred systems. Even though, there is a limited number of studies related to AVGs nowadays, interest in the studies conducted in this field is still increasing, as this technology becomes an even more important part of our lives. Over the recent years, more research has started to be conducted with regards to AVGs. American Heart Association (AHA) and Nintendo are currently implementing a joint project to investigate whether AVGs fulfill the exercise intensity criteria recommended by the AHA. In the same manner, American Diabetes Association (ADA) is holding similar talks with the game brand Konami. In a study conducted by Ainsworth et al. [17] it has been shown that AVGs can increase the energy consumption up to 7.2 MET. Research findings on this field has also brought support for AVGs technology by the healthcare industries to increase the level of physical activity into question. In this context, the purpose of this review was to provide an overview of the literature on the use of AVGs for physical activity.

MATERIAL AND METHODS

This review includes studies reported the oxygen consumption (VO_2), heart rate (HR), respiratory exchange rate (RER), energy expenditure (EE), and metabolic equivalent (MET) data investigated in AVGs. In the scope of this study of database such as "Google scholar" and "pubmed" were used, and the search was done using the keywords such as "exer-game", "active video game", "active game", "exer-gaming", "Xbox Kinect", and "Kinect". Review articles were not used in this manuscript, but related review articles were also searched to reach the relevant studies. Sixty-six articles has been scanned in total, but 32 of them has been extracted. Studies that investigated the motor development [18,19], aimed the rehabilitation [19,20] and examined the disabled individuals [21,22] has been excluded.

Literature

Eleven articles have been viewed to determine the impact of AVGs on physiological variables. One of them was cited only in text, and the other ten studies' findings were summarized in Table 1. Studies conducted with AVGs have generally been carried out with adolescents [23] and obese individuals [24], and these studies have examined the impact of AVGs on physiological variables. In these studies, the physiological variables are limited to VO_2 , HR and EE [23,25-29].

Studies conducted with AVGs generally have compared the AVGs and passive video games and/or the AVGs and resting and sedentary situations (e.g. watching television etc.) [23,25,27,29-31].

Furthermore, also there are studies where different AVGs are compared with each other [25,30,32,33]. Moreover, current literature has included studies which compare different AVGs consoles [28,29,31], and which compare AVGs with traditional exercises [23,26,27]. The Table 1 represents a general summary of the results obtained with regards to the physiological responses of AVGs within the published studies.

RESULTS

Comparison of Active Video Games with Sedentary Situations

It has been determined that the AVGs played with Nintendo Wii, Sony Play Station - Eye Toy Move and Microsoft Xbox Kinect consoles result in significantly higher EE in comparison to sedentary situations or passive video games [23,25,27,29-31]. Clevenger and Howe [25] reported that AVGs played between 6-10 minutes significantly increased amount of EE in 8 - to 17 - year old adolescents in comparison to passive video games. Therefore, individuals who do not exercise and prefer sedentary games can be encouraged to play games in an entertaining environment and exercise with AVGs.

White et al. [23] have examined the impact of AVGs played with Nintendo Wii (bowling, boxing, tennis, skiing and step) on the VO_2 in small boys ($n = 26$ male; mean age = 11.4 years). The amount of VO_2 consumed during different AVGs were determined to be significantly higher than the values obtained at rest ($p < 0.001$). In the same manner, several studies have reported that the amount of VO_2 consumed during AVGs is significantly higher than the amount of VO_2 consumed during sedentary conditions (e.g. during resting, watching television, and playing passive games) [23,25,27,29-31].

The study conducted by Clevenger and Howe [25] compared six different AVGs ('Disney Rush, Skiing, Reflex Ridge, Zumba/Your Shape, Wipeout and Dance Central) and four different passive video games, and investigated the HR values. The HR values recorded during AVGs have been determined as 119.5 ± 2.9 , 125.3 ± 2.6 , 146.6 ± 2.9 , 128.5 ± 3.3 , 143.6 ± 5.1 , and 135.1 ± 5.5 respectively, and they have been found significantly higher than the HR values recorded during passive video games (mean HR = 91.8 ± 2.0 beat/min) [25]. In the mentioned study the MET value has been recorded as 1.6 - 1.8 (MET) during the passive video games [25]. On the other hand, the MET values recorded during AVGs are much higher [30]. The MET values have been recorded lower than 2.4 (MET) during AVG tennis and AVG baseball; therefore, these two AVGs have been categorized as very low intensity exercise. However, the MET values determined during AVG boxing have been recorded between 2.4 - 4.7 (MET) and therefore it has been classified as low intensity exercise. Finally, the MET values determined during AVG jogging were between 4.8-7.1 (MET) and therefore it has been classified as moderately intense exercise [30]. Consequently, many studies have determined AVGs as moderately intense exercise in accordance with ACSM criteria (3-6 MET[34]) [25,29].

Comparison of Different Active Video Game Consoles

Marks et al. [28] have conducted a study on 15 adolescents who play the boxing and dancing games for 10 minutes with Nintendo Wii and Xbox Kinect consoles, and compared the EE amounts ($\text{kcal} \cdot \text{kg}^{-1} \cdot \text{s}^{-1}$). It has been reported that the EE amount was significantly higher for Xbox Kinect game console (boxing = 3.0 versus 4.6 $\text{kcal} \cdot \text{kg}^{-1} \cdot \text{s}^{-1}$, dancing = 3.3 versus 4.1 $\text{kcal} \cdot \text{kg}^{-1} \cdot \text{s}^{-1}$, respectively). In the mentioned study, the HR values have been recorded as 124.9 ± 13.0 and 115.4 ± 12.8 beats·minute⁻¹ for the boxing game and 111.5 ± 12.3 and 110.1 ± 14.5 beats·minute⁻¹ for the dancing game. Consequently, the HR was observed significantly higher during the boxing game played with Xbox Kinect ($p < 0.05$). Another study compared the amount of EE recorded during single-player or multi-player games on Xbox Kinect and Nintendo Wii game consoles ($n = 14$; mean age = 21 years) [29]. It has been reported that the games played on Xbox Kinect console resulted in higher EE compared to Nintendo Wii, and multi-player games caused higher EE in comparison to the single-player games (multi-player = 7.19 ± 2.07 versus 6.15 ± 2.31 ($\text{kcal} \cdot \text{min}^{-1}$), single-player = 6.78 ± 1.82 versus 4.96 ± 1.51 ($\text{kcal} \cdot \text{min}^{-1}$), respectively). Similar findings have also been reported for HR; higher HR values have been recorded during multi-player AVGs [29].

Comparison of Active Video Games with each other

In a study conducted with Xbox Kinect, the participants played AVGs in different songs. As the rhythm increased in different music genres, it has been shown that the number of steps have increased; therefore, the intensity of exercise has also increased. Consequently, higher VO_2 amount and higher HR values were recorded [33]. During the AVGs played at low intensity the HR was recorded as 138 beats·min⁻¹, whereas during the AVGs played at high intensity the HR was recorded as 190 beats·min⁻¹ [33]. Graves et al. [27] conducted a study with Nintendo Wii where the participants played AVG yoga, AVG balance, AVG muscle coordination and AVG aerobic, and during these games 1.9, 1.9, 2.4, and 3.6 MET values were recorded, respectively. Only one study has reported that AVG dance performance is equivalent to high intense exercise (> 6 MET; ACSM, 2014) [33]. Only one study has examined the RER and reported mean value as 1.07±0.10 during AVGs. This indicates that AVGs are equivalent to a high intense exhausting exercise close to maximum effort during the games (when pauses between games are not taken into account).

Comparison of Active Video Games with Traditional Exercise

AVGs (Nintendo Wii) have been compared with traditional exercises; AVG bowling, AVG boxing, AVG tennis, AVG skiing, and AVG step exercises were compared with walking and running. No significant differences were determined between HR during AVGs and walking, but HR during running was greater than all AVGs [23]. In addition, it has been reported that, although exercise intensities were constant (65% of age predicted HRpeak), the rate of perceived exertion was significantly lower for AVG boxing and tennis compared with traditional exercise modes [26]. In accordance with these findings, Chaput et al. [24] indicated that the rate of perceived exertion was significantly higher during cycling exercise (6.5±1.2) compared with AVG boxing (4.5±1.2).

DISCUSSION

The objective of this review was to present a general perspective within the framework of the general literature on certain physiological effects of AVGs. All examined studies have reported higher physiological responses during AVGs in comparison to the values recorded during rest. When different AVGs consoles are compared, it has been discovered that Xbox Kinect caused significantly higher VO_2 , EE, and HR responses.

The current literature findings have demonstrated that, exercising with AVGs fulfilled the criteria for highly intense exercise (>6 MET) or for low/moderately intense exercise (<6 MET) according to ACSM criteria. As time goes on, people play more computer games and spend longer time in front of a computer. Therefore, AVGs can be considered as an alternative exercise model to increase the physical activity level and combat obesity. However, it should be noted that the characteristics of the population who perform the AVGs (e.g. age, gender, suitability for physical activity, skill level etc.), the characteristic structure of the AVGs console (whether the console can sense the entire body or not) and the AVGs itself (the selected AVGs for playing; e.g. dance, fighting, yoga etc.) would alter the physiological responses obtained.

Studies focused on AVGs generally have investigated the acute effects [23,25-27,29-33] and play periods have ranged between 6 and 30 minutes. These studies have presented findings showing that general games provided low and moderate intense physical activity [23,29,30]. During studies conducted in laboratories - as they are different than home environments - AVGs were played between 10 and 30 minutes on average and in general, acute effects were examined. However, this situation can become a part of the daily life for those individuals who play AVGs at home, and they can spend time of 30 minutes per day to play AVGs. Therefore, it would be more appropriate for the future studies to examine long-term and chronic effects of AVGs. In this way, the possibility of obtaining higher energy consumption data would increase.

When it is considered that the AVGs technology is initially developed for use at home, researches planned to be conducted in relation to this subject are recommended to be applied on different populations with special requirements. Especially, long-term studies based on the home environment could reveal more clearly the long-term effects of AVGs on health and fitness.

Table 1. Summary of the findings of selected studies with regard to oxygen consumption, heart rate, energy expenditure, and metabolic equivalent.

| References | Participants | AVG Activities | Duration Min | Variables | | | |
|--------------------------------|--|----------------------------|-----------------|-----------------|---------------------|--------------------------------|---------------|
| | | | | VO ₂ | EE | MET | HR (beat/min) |
| O'Donovan and Hussey. [30] | 18M+10F Mean age=22 years | Wii boxing | 15 | 13.5 ml/kg/min. | 305.5 kJ/15 min. | 3.2 | 58% [HRpeak] |
| | | Wii tennis | | 7.7 ml/kg/min. | 171.9 kJ/15 min. | 2.0 | 42% [HRpeak] |
| | | Wii baseball | | 8.0 ml/kg/min. | 179.0 kJ/15 min. | 2.0 | 42% [HRpeak] |
| | | Wii jogging | | 25.7 ml/kg/min. | 594.2 kJ/15 min. | 5.9 | 71% [HRpeak] |
| O'Donovan et al. [29] | n=14 Mean age=20.8 years | Kinect Reflex Ridge Single | 10 | 17.9 ml/kg/min. | 6.8 kcal/min. | 4.3 | 114 |
| | | Kinect Reflex Ridge Multi | | 18.3 ml/kg/min. | 7.2 kcal/min. | 4.5 | 118 |
| | | Wii Sports Boxing Single | | 13.3 ml/kg/min. | 4.9 kcal/min. | 3.1 | 107 |
| | | Wii Sports Boxing Multi | | 16.5 ml/kg/min. | 6.2 kcal/min. | 3.9 | 119 |
| Clevenger et al. [25] | 36M+22F Mean age=12.1±2.3 years | Disney Rush | 6-10. | 3.4 L/min. | - | Lowest Disney Rush: 2.8 | 119.5 |
| | | Skiing | | 5.5 L/min. | - | | 125.3 |
| | | Reflex Ridge | | 6.5 L/min. | - | | 146.6 |
| | | Zumba | | 9.1 L/min. | - | 128.5 | |
| | | Wipe out | | 11.9 L/min. | - | 143.6 | |
| | | Dance Central | | 10.2 L/min. | - | Highest Wipe out: 6.6 135.1 | |
| Marks, Rispen and Calara, [28] | 8M+7F Mean age=21.3±1.4 years | Wii Boxing | 10 | 10.0 ml/kg/min. | 3.0 kcal/kg/hr. | - | 115.4 |
| | | Kinect Boxing | | 15.3 ml/kg/min. | 4.6 kcal/kg/hr. | - | 124.9 |
| | | Wii Just Dance 2 | | 10.9 ml/kg/min. | 3.3 kcal/kg/hr. | - | 110.1 |
| | | Kinect Just Dance 2 | | 13.7 ml/kg/min. | 4.1 kcal/kg/hr. | - | 111.5 |
| Noah et al. [33] | 4M+8F Mean age=27.2±1.3 years | Dance Dance Revolution | 6 songs | 28.5 ml/kg/min. | 9.4 kcal/min. | 8.0 | 156.8 |
| Lanningham-Foster et al. [32] | 22 children (11M+11F) Mean age=12.1±1.7 years | Sit watch TV | 10 | - | 1.6 [kcal/hr]/kg BW | - | - |
| | | Stand watch TV | | - | 1.8 [kcal/hr]/kg BW | - | - |
| | | Sedentary video game | | - | 1.7 [kcal/hr]/kg BW | - | - |
| | | Nintendo Wii sports boxing | | - | 5.1 [kcal/hr]/kg BW | - | - |
| | 20 adults (10M+10F) Mean age=33.5±10.7 years | Sit watch TV | 10 | - | 0.9 [kcal/hr]/kg BW | - | - |
| | | Stand watch TV | | - | 1.1 [kcal/hr]/kg BW | - | - |
| | | Sedentary video game | | - | 1.0 [kcal/hr]/kg BW | - | - |
| | | Nintendo Wii sports boxing | | - | 2.7 [kcal/hr]/kg BW | - | - |

M=male; F=female; BW=body weight; AVG=active video game; VO₂=oxygen consumption; EE=energy expenditure; HR=heart rate; MET = metabolic equivalent.

Table 1. Summary of the findings of selected studies with regard to oxygen consumption, heart rate, energy expenditure, and metabolic equivalent (continue).

| References | Participants | AVG Activities | Duration Min | Variables | | | |
|--------------------|--|--------------------------|--------------|-----------------|----------------|----------------|----------------------|
| | | | | VO ₂ | EE | MET | HR (beat/min) |
| White et al. [23] | 26 boys Mean age = 11.4 ± 0.8 years | Watching television | 10 | 6.9 ml/kg/min | 142 J (kg/min) | 1.0 | 83 [42 % of HRpeak] |
| | | Ps3 | | 7.5 ml/kg/min | 150 J (kg/min) | 1.1 | 85 [43 % of HRpeak] |
| | | Wii tennis | | 14.1 ml/kg/min | 289 J (kg/min) | 2.2 | 106 [52 % of HRpeak] |
| | | Wii Bowling | | 14.0 ml/kg/min | 277 J (kg/min) | 2.0 | 107 [53 % of HRpeak] |
| | | Wii boxing | | 20.2 ml/kg/min | 411 J (kg/min) | 3.1 | 140 [72 % of HRpeak] |
| | | Wii step | | 17.0 ml/kg/min | 350 J (kg/min) | 2.4 | 122 [62 % of HRpeak] |
| | | Wii ski | | 11.3 ml/kg/min | 230 J (kg/min) | 1.7 | 113 [58 % of HRpeak] |
| | | Walking | | 19.6 ml/kg/min | 403 J (kg/min) | 3.0 | 115 [58 % of HRpeak] |
| | | Running | | 37.4 ml/kg/min | 768 J (kg/min) | 5.6 | 173 [87 % of HRpeak] |
| Graves et al. [27] | 14 adolescents 10 M + 4 F 11-17 years old | Handled gaming | 10 | 0.4 L/min. | 113.5 J/kg/min | 1.0 | 70.9 |
| | | Wii yoga | | 0.6 L/min. | 190.8 J/kg/min | 1.7 | 86.6 |
| | | Wii muscle | | 0.7 L/min. | 236.8 J/kg/min | 2.2 | 90.2 |
| | | Wii balance | | 0.6 L/min. | 188.2 J/kg/min | 1.7 | 85.0 |
| | | Wii aerobics | | 1.1 L/min. | 348.1 J/kg/min | 3.2 | 101.9 |
| | | Brisk treadmill walking | | 1.2 L/min. | 384.9 J/kg/min | 3.5 | 111.8 |
| | | Treadmill jogging | | 2.2 L/min. | 697.7 J/kg/min | 6.5 | 154.9 |
| | 15 young adults 7 M + 8 F 21-38 years old | Handled gaming | 10 | 0.3 L/min. | 109.0 J/kg/min | 1.1 | 65.6 |
| | | Wii yoga | | 0.6 L/min. | 178.8 J/kg/min | 1.9 | 77.6 |
| | | Wii muscle | | 0.7 L/min. | 230.2 J/kg/min | 2.4 | 82.4 |
| | | Wii balance | | 0.6 L/min. | 182.8 J/kg/min | 1.9 | 76.7 |
| | | Wii aerobics | | 1.1 L/min. | 345.3 J/kg/min | 3.6 | 94.5 |
| | | Brisk treadmill walking | | 1.4 L/min. | 429.7 J/kg/min | 4.5 | 108.3 |
| | | Treadmill jogging | | 2.4 L/min. | 764.7 J/kg/min | 8.0 | 153.7 |
| | 13 older adults 10 M + 3 F 45-70 years old | Handled gaming | 10 | 0.3 L/min. | 84.1 J/kg/min | 1.1 | 74.0 |
| | | Wii yoga | | 0.6 L/min. | 148.7 J/kg/min | 1.9 | 83.8 |
| | | Wii muscle | | 0.7 L/min. | 178.7 J/kg/min | 2.3 | 86.8 |
| | | Wii balance | | 0.6 L/min. | 150.8 J/kg/min | 1.9 | 84.5 |
| | | Wii aerobics | | 0.9 L/min. | 252.2 J/kg/min | 3.2 | 94.7 |
| | | Brisk treadmill walking | | 1.2 L/min. | 302.7 J/kg/min | 4.0 | 102.5 |
| | | Treadmill jogging | | - | - | - | - |
| Scheer et al. [31] | 10 M (20.1 ± 0.4 years); 9 F (19.8 ± 0.3 years) | Wii boxing | 8 | 9.2 ml/kg/min | 3.5 kcal/min | Games mean 2.8 | 115.5 |
| | | Kinect boxing | | 10.6 ml/kg/min | 4.2 kcal/min | | 119.3 |
| | | Move gladiatorial combat | | 9.6 ml/kg/min | 3.8 kcal/min | | 120.2 |

M=male; F=female; BW=body weight; AVG=active video game; VO₂=oxygen consumption; EE=energy expenditure; HR=heart rate; MET = metabolic equivalent.

Table 1. Summary of the findings of selected studies with regard to oxygen consumption, heart rate, energy expenditure, and metabolic equivalent (continue).

| References | Participants | AVG Activities | Duration Min | Variables | | | |
|--------------------|--|----------------------------------|--------------|-----------------|------------|-----|---------------|
| | | | | VO ₂ | EE | MET | HR (beat/min) |
| Chaput et al. [24] | 19 boys obese adolescents Mean age = 14.5 ± 0.8 years | Control session - seated at rest | 60 | - | 98±5 kcal | - | 71±1 |
| | | Passive video game - boxing | 60 | - | 125±7 kcal | - | 87±7 |
| | | Active video game - boxing | 60 | - | 370±4 kcal | - | 119±1 |
| | | Cycling exercise * | 44±5 | - | 358±3 kcal | - | 138±5 |

M=male; F=female; BW=body weight; AVG=active video game; VO₂=oxygen consumption; EE=energy expenditure; HR=heart rate; MET = metabolic equivalent.

* The duration of cycling exercise was calculated individually in order to equate energy expenditure to active video game session.

Additionally, AVGs can be integrated to the developing technologies such as virtual reality, and in this way, people can exercise for longer periods without getting bored and enjoy themselves. It should be emphasized that in light of all of these data, the technology can be evaluated not only for its contributions to easier life, but also for its contributions to a healthier lifestyle.

CONCLUSIONS

Consequently, the findings of the recent literature demonstrated that the amount of VO₂, EE, HR, and MET values have increased significantly during AVGs compared with the resting state. It has been observed that the physiological responses are related to the brand of the game console and its structure, as well as, the characteristic structure of selected AVGs for playing. In addition to these, it has been indicated that the AVGs are equivalent to moderately intense exercise from the perspective of ACSM criteria. Therefore, the AVGs can actually be considered among the exercise models for the future.

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