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ORIGINAL ARTICLE

Active videogames promotes cardiovascular benefits in young adults? Randomized controlled trial☆

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KEYWORDS
Virtual reality;
Heart rate;
Blood pressure;
Double product

Abstract
Objectives: To investigate how quickly active video games, structured and unstructured, provide changes in hemodynamic variables in young adults during a 6-week intervention.
Method: Twenty participants after baseline assessments, participants were randomized: structured active videogame ($n = 6$), unstructured active videogame ($n = 7$) and a control group ($n = 7$). Participants played their respective active videogame 3 times a week for 6-weeks (30 min-session).
Results: Structured active videogame in exactly 6 weeks shown improvements reducing the heart rate (heart rate; 14% of variation; $p < 0.05$). Otherwise, not confirmed to both active videogame interventions in systolic blood pressure but maintain the diastolic blood pressure during these 6 weeks (systolic blood pressure-unstructured: −2% and Structured: 11%; diastolic blood pressure-unstructured: 0% and structured: 0%; $p > 0.05$).
Conclusions: The 6-week training program with active videogame reduced the heart rate (structured – 6th week). However, active videogames generally do not promoted benefits for normotensive young adults.

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PALAVRAS-CHAVE
Realidade virtual;
Frequência cardíaca;
Pressão sanguínea;
Duplo produto

Videogames ativos promovem benefícios cardiovasculares em adultos jovens? Ensaio clínico randomizado

Resumo
Objetivos: Investigar o quão rápido os videogames ativos, estruturados e não estruturados, proporcionam mudanças em variáveis hemodinâmicas em adultos jovens durante uma intervenção de seis semanas.
Método: Foram randomizados 20 participantes após avaliações iniciais: videogame ativo estruturado (n = 6), videogame ativo não estruturado (n = 7) e um grupo controle (n = 7). Os participantes fizeram seu respectivo videogame ativo três vezes por semana durante seis semanas (30 minutos por sessão).
Resultados: videogame ativo estruturado em exatamente seis semanas mostrou redução da frequência cardíaca (frequência cardíaca; 14% de variação; p < 0,05). Por outro lado, não confirmou em ambas as intervenções de videogame ativo pressão arterial sistólica, porém manteve a pressão arterial diastólica durante essas seis semanas (pressão arterial sistólica não estruturada: -2% e estruturadas: 11%; pressão arterial diastólica não estruturada: 0% e estruturada: 0%; p < 0,05).
Conclusão: O programa de treinamento de seis semanas com videogame ativo reduziu o frequência cardíaca (estruturado seis semanas). Porém, de forma geral, os videogames ativos não promoveram benefícios em adultos jovens normotensos.

PALABRAS CLAVE
Realidad virtual;
Frecuencia cardíaca;
Presión sanguínea;
Doble producto

¿Los videojuegos activos promueven beneficios cardiovasculares en adultos jóvenes? Ensayo clínico de distribución aleatoria

Resumen
Objetivos: Analizar la rapidez con la cual los videojuegos activos, estructurados y no estructurados, generan cambios en las variables hemodinámicas en adultos jóvenes durante una intervención de 6 semanas.
Método: Se distribuyó aleatoriamente a 20 participantes según las evaluaciones iniciales: videojuego activo estructurado (n = 6), videojuego activo no estructurado (n = 7) y grupo control (n = 7). Los participantes jugaron con sus respectivos videojuegos activos 3 veces por semana durante 6 semanas (sesiones de 30 minutos).
Resultados: Los videojuegos activos estructurados en exactamente 6 semanas mostraron que reducían la frecuencia cardíaca (frecuencia cardiaca; 14% de la variación; p <0,05). En cambio, no se confirmó en ambas intervenciones de videojuegos activos la presión arterial sistólica, pero se mantuvo la presión arterial diastólica durante estas 6 semanas (presión arterial sistólica en no estructurados: -2% y en estructurados: 11%; presión arterial diastólica en no estructurados: 0% y en estructurados: 0%, p >0,05).
Conclusiones: El programa de entrenamiento de 6 semanas con videojuegos activos redujo la frecuencia cardiaca (estructurado - sexta semana). Sin embargo, de forma general los videojuegos activos no promueven beneficios en adultos jóvenes normotensos.

Introduction

According to the guidelines about recommendations for exercise, young adults should perform 30–60 min of moderate physical activity (50–69% of maximal heart rate) at least 3 days a week to maintain the cardiovascular health (I Brazilian Hypertension Guidelines 2013; Garber et al., 2011). Nevertheless, the sedentary life style is occur ring in parallel to the development of numerous technological advancements that result in individuals spending more of their day on ''*screen time*''(Altenburg et al., 2012), that is defined as time spent on watching TV, using computers, smartphones, tablets and playing videogames (Christie and Trout, 2007).

To change these habits, exist several types of physical actives with trends to each one (Booth et al., 2014), one of them is the active videogames (AVGs) have been used because they can acutely elevate the heart rate (HR) during the gaming (Brito-Gomes et al., 2014) and promote hemodynamic responses in blood pressure (BP) (Perrier-Melo et al., 2013) reaching the intensity recommended by the guidelines. In another hand, knowing the negative correlation between screen time and BP is observed the occurrence of chronic degenerative diseases (Altenburg et al., 2012) such as hypertension, obesity and diabetes, elevating the cardiovascular risks.

Thus, some fewer long-term studies have been using to analyze the effects of this tool. In a 28 week-intervention with a transversal analysis at the 10th week by the same variables, there were no significant differences on HR, SBP (systolic blood pressure) and DBP (diastolic blood pressure) at the 28th week in relation to baseline using an unstructured AVG (in exception the SBP at the 10th week) (Maloney et al., 2008). The same was observed in another study after 12 week-intervention, with no statistical changes at these variables (Kempf and Martin, 2013). However, statistical reductions in SBP after 6 weeks were found in structured AVG (Warburton et al., 2007) but not in DBP.

If any physical activity, such as AVG, is used to improve fitness with cardiovascular characteristics, they may promote hemodynamic benefits (Haskell et al., 2007), such as in the resting HR or SBP analysis for example because of the cardiac output (McArdle et al., 2003). Therefore, in overview of AVG, there are two primary types (Gomes, 2015; Melo, 2015; Brito-Gomes et al., 2015): unstructured AVG which are designed for recreation, motivation, and/or rehabilitation (Falcade et al., 2013; Perrier-Melo et al., 2013; Taylor et al., 2012) and structured AVG which are designed to improve physical fitness within a virtual reality by adhering to the principles of sport training (Christie and Trout, 2007; Warburton et al., 2007; Brito-Gomes et al., 2015).

Thus, while evidence support the use of structured AVGs (with moderate intensity of physical activities) promote hemodynamic benefits after 6 weeks, and the use of the unstructured AVG maybe present benefits if used in a medium-long term, however, due to the pre-post methodology of analysis is impossible to show any change. There remain critical gaps in the literature: how quickly do structured and unstructured AVGs decrease the resting SBP, HR and (or promote maintenance on) DBP. Thereby the primary purpose of this investigation was to analyze how quickly AVGs, structured and unstructured, provide benefits in cardiovascular variables in young adults, improving their fitness, resulting in better results during a 6-week intervention. We hypothesized that structured AVG will reduce more quickly resting heart rate, blood pressure and double product than unstructured because the characteristics of the game. Once the structured AVG should have evolution based in the principle's prescriptions of the exercise.

Material and methods

Design and participants

This Brazilian randomized controlled trial (registration number: U1111-1159 7242) which was conducted in the Human Performance Laboratory – UPE/ESEF. Participants included: 24 volunteer normotensive university students between 18 and 25 years of age (age: 19.8 ± 2.0 years, height: 1.78 ± 0.07 m, body mass: 73.0 ± 9.5 kg). All participants were healthy eutrophic males who were physically inactive (3 months with no practice of structured physical activities) and had no previous experience playing AVGs. All participants read and signed the informed consent form approved by the University of Pernambuco (UPE) Research Ethics Committee (#577 277) prior to participation according 466/2012 Resolution. Additionally, all participants were screened using the Physical Activity Readiness Questionnaire (PAR-Q) prior to initiating the investigation. Once eligible, participants underwent baseline testing to determine the body mass, height, resting heart rate, blood pressure and aerobic capacity.

Study design

After completing the baseline assessment, participants were randomized to one of three groups: (a) unstructured AVG (Kinect Sports: Boxing), (b) structured (Nike Kinect Training) and (c) control (normal daily activities). The scores of aerobic capacity were computed in a ranking the highest to lowest and they were allocated following the order: (1) unstructured; (2) structured; (3) control; (4) control; (5) structured; (6) unstructured; restarting the cycle until completing the groups. Each treatment group then performed an AVG familiarization session. The unstructured group (Boxing – Kinect Sports – https://www.youtube.com/watch?v=uF1KApa7hRE) performed 20 min of gaming and was allowed to see the tutorial videos of the game. The structured group (Nike Kinect Training – https://www.youtube.com/watch?v=D5glY_K8u14) performed a brief evaluation (~20 min) that the AVG provides to prescribe the exercises that will be performed during gameplay and was allowed to see the tutorial videos of the game.

All training sessions were completed with an Xbox 360° Kinect console. All AVGs were displayed, via a multimedia projector (Power Lite S10+, EPSON) mounted to the laboratory ceiling, on a wall with an image size of approximately 1.3 m high by 1.6 m wide (82 in.). Sound was broadcast via a single amplified speaker (COM 126 Professional, ONEAL, Brazil) connected to the Xbox 360° console. The laboratory was keep at 24 ± 2 °C, with 40–60% relative humidity (Environmental Station, Barigo, Germany). The types of active videogames used were boxing (Kinect Sports) and functional physical activities (Nike Kinect Training), which are divided according Table 1.

Two days (48 h) after baseline testing and game orientation, participants initiated the 6-week intervention. Each participant completed 3 sessions per week for each week of the intervention of 18 sessions (30 min each). The Unstructured AVG is composed by various 3-min round of punches

Table 1 Types and characteristics of active videogames.

Types of AVG	Characteristics	Examples
Structured AVG	Uses basic exercises such as squates, push-ups, cycling. Incorporates planned movement patterns. Movement pattern feedback may or may not be provided based on the operating system.	Gym games Your Shape Fitness Game Bike Nike Kinect Training
	Systematic order of exercise progression and/or intensity (e.g. sets, reps, rate, duration).	
Unstructured AVG	Activities that do not mimic formal exercises but rather sporting movements and general body movements.	Boxing
		Volleyball
	Players are free to move as they wish during game play and there is no formal progression to higher levels of physical activity difficulty as game play progresses.	Table tennis
		Dance dance revolution

Modified from Brito-Gomes et al. (2015).

against the computer and the participant can move to sides and undertake short squats to give a hook. The structured AVG is composed by different functional exercises using the body mass doing flexion, extension, adductions, abductions and circumduction of limbs and shoulder and pelvis cinctures. Also, move to sides, jump and stationary running.

Participants in the experimental groups were required to complete at least 85% of the training sessions or they would be dropped from the investigation. The control group kept with their normal daily activities with no structured physical activities. After the first assessment (Baseline) in each begin of the subsequently week (following the final training session; 3-week sessions) participants completed another six assessments of HR, SBP and DBP using the methodology described for the baseline assessment.

Procedures and instruments

In baseline, body mass in kilograms was measured using a mechanical scale (Filizola, Brazil), with accuracy of 0.1 kg. Height was measured in centimeters using a wooden stadiometer fitted with a scale in millimeters. Anthropometric measurements were performed by trained professionals and obeyed by ISAK standardized international techniques (Stewart et al., 2012). Then body mass and stature were used to calculate the Body Mass Index (BMI) by kilogram per square stature.

After, the hemodynamic measurements were monitored in the rest of five minutes in seated position. The heart rate (HR) was assessed by using a Polar FT1 (Polar, Finland) heart rate monitor. Next the systolic (SBP) and diastolic (DBP) blood pressure were measured by the automated method (OMRON HEM-7113) according to Guidelines of Brazilian Hypertension (Nobre, 2010). The resting double product was calculated using the systolic blood pressure multiplied by heart rate.

After, we determined the individuals' aerobic capacity as a sample characterization parameter. All participants wore a facemask and adult head cap (Metalyser, Germany) connected to a metabolic gas analyzer (CPX/D, Cortex, Germany) during a maximal Astrand-Ryhming cycle test performed on a Cateye EC-1600 Ergociser (Ergociser, Japan) following the protocol used by ASCM of Astrand and Ryhming (1954). In brief, this test is completed by initial 2 min of warming with 25 W of load. After was added 75 W to keep into 100 W during 2 min. Next each 2 min was added 50 W reaching until the fatigue.

For the baseline and all subsequent assessments (only HR, SBP and DBP), participants were instructed to wear minimal clothing, to avoid moderate or vigorous exercise for 24 h prior to testing, to eat at least three hours before the assessments, and to refrain from alcohol and smoking the day prior to the assessments.

Data analysis

All data initially underwent tests of normality (Shapiro–Wilk). After determining normal distribution of the data, the baseline data were compared among the control, structured AVG and unstructured AVG groups using one-way ANOVA to each variable. Change in resting heart rate, blood pressure and double product over the weeks was assessed using a repeated measures (intragroup). ANOVA. Bonferroni's post hoc test was used to identify the location of significant differences if appropriate. An additional ANOVA one way was performed to verify the differences of the groups at the end of the study. An a priori alpha level of 0.05 was adopted for all statistical tests in Graph Pad Prism 5.0 program.

Results

In total four participants were excluded for failing to complete at least 85% of the training sessions. The demographic characteristics and baseline assessments of the remaining 20 participants are show in Table 2. The initial analysis over the variables among the groups shows no differences at the baseline moment ($p > 0.05$).

Table 2 Characterization of sample characterization recruited for the study ($n = 20$).

Variable	Unstructured ($n = 7$)	Structured ($n = 6$)	Control group ($n = 7$)	p value
Age (years)	18.8 ± 0.9	19.0 ± 1.0	21 ± 3	0.454
Body mass (kg)	72.3 ± 10.2	71.7 ± 13.7	69.2 ± 8.1	0.616
Height (m)	1.70 ± 0.05	1.70 ± 0.06	1.77 ± 0.07	0.746
BMI (kg/m^2)	22.6 ± 2.0	23.6 ± 3.3	22.2 ± 4.3	0.545
HR (bpm)	79.0 ± 12.7	69.3 ± 5.2	78.0 ± 8.5	0.292
SBP (mmHg)	125.4 ± 10.8	124.8 ± 12.0	117.1 ± 11.3	0.333
DBP (mmHg)	68.5 ± 4.3	69.5 ± 7.7	69.6 ± 8.9	0.960
DP (mmHg bpm)	9717 ± 2147	8316 ± 1152	9779 ± 709	0.695
AE (mL/kg/min)	36.0 ± 5.2	39.0 ± 5.9	37.9 ± 3.3	0.572

BMI, body mass index; HR, heart rate; DBP, diastolic blood pressure; DP, double product; AE, aerobic capacity; SBP, systolic blood pressure.

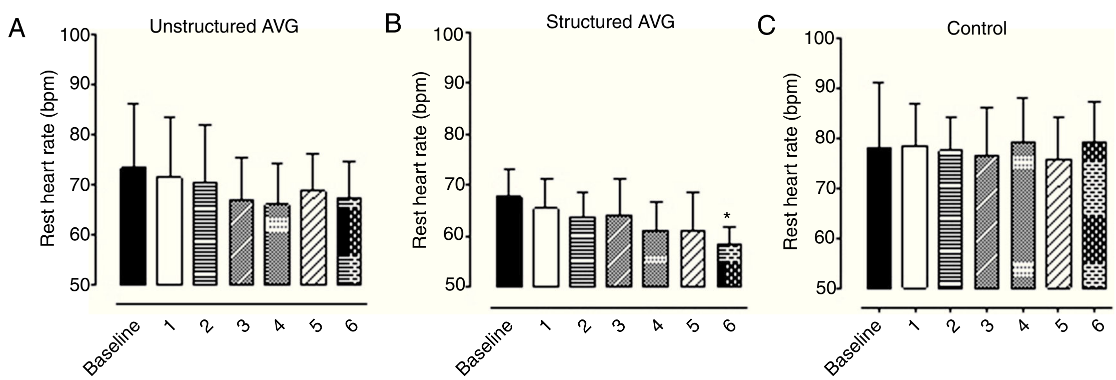

Figure 1 Resting heart rate of the AVG's intervention and control group during the weeks. 1, 2, 3, 4, 5 and 6: Indicates the measurements of each week training. *$p < 0.05$ in relation to baseline.

The resting heart rate of the AVG's intervention and control group during the weeks are presented in Fig. 1. The unstructured AVG (panel A) reduced but with no significant difference ($p = 0.061$). The structured AVG (panel B) shown difference only at the sixth week ($p = 0.003$). The control group (panel C) did not shown significant difference ($p = 0.734$). A percentage's variation at the end of the study in relation to the baseline shown values with 8%, 14% and −1%, respectively.

Fig. 2 shows systolic and diastolic blood pressure of the AVG's intervention and control group during the weeks. Compared to baseline, during and post intervention, in SBP no groups shown statistical differences with p-values of: the unstructured AVG (panel A; $p = 0.628$); the structured AVG (panel B; $p = 0.121$) and the control group (panel C; $p = 0.718$). The same verified in DBP of the AVG's intervention and control group shown no statistical differences with p-values of: the unstructured AVG (panel D; $p = 0.910$); the structured AVG (panel E; $p = 0.272$) and the control group (panel F; $p = 0.502$). A percentage's variation in the SBP at the end of the study in relation to the baseline shown values with −2%, 11% and −1%, respectively. A percentage's variation in the DBP at the end of the study in relation to the baseline shown values with 0%, 0% and 5%, respectively.

The resting double product of the AVG's intervention and control group during the weeks are present in Fig. 3. Statistical differences were observed in the Unstructured AVG ($p = 0.021$) in the fourth week, however, no differences in the Structured AVG ($p = 0.141$) and the control group ($p = 0.745$). A percentage's variation at the end of the study in relation to the baseline with values were 7%, 11% and −2%, respectively.

An additional ANOVA was performed to verify the differences of the groups at the end of the study. And, in the final of the study was difference by RHR of control group vs unstructured and vs structured AVG ($p = 0.000$). But no difference to RSBP ($p = 0.2240$) and RDBP ($p = 0.734$). However, the RDP of structured AVG group was different vs control group ($p = 0.018$).

Discussion

The present study analyzes the impact of six weeks engagement in two different active video games program (structured and unstructured) on hemodynamic variables (heart rate, blood pressure and double product) in normotensive individuals. Despite seeing clinical benefits, in general, no significant differences were seen. Thus, the results demonstrated weeks of structured training with AVG improve their fitness reducing the resting heart rate. Otherwise, both AVG interventions were not enough to promote significant reductions in SBP and DBP in the analyzed groups. In addition, however, it can be noted significant decreases on double product obtained by the unstructured

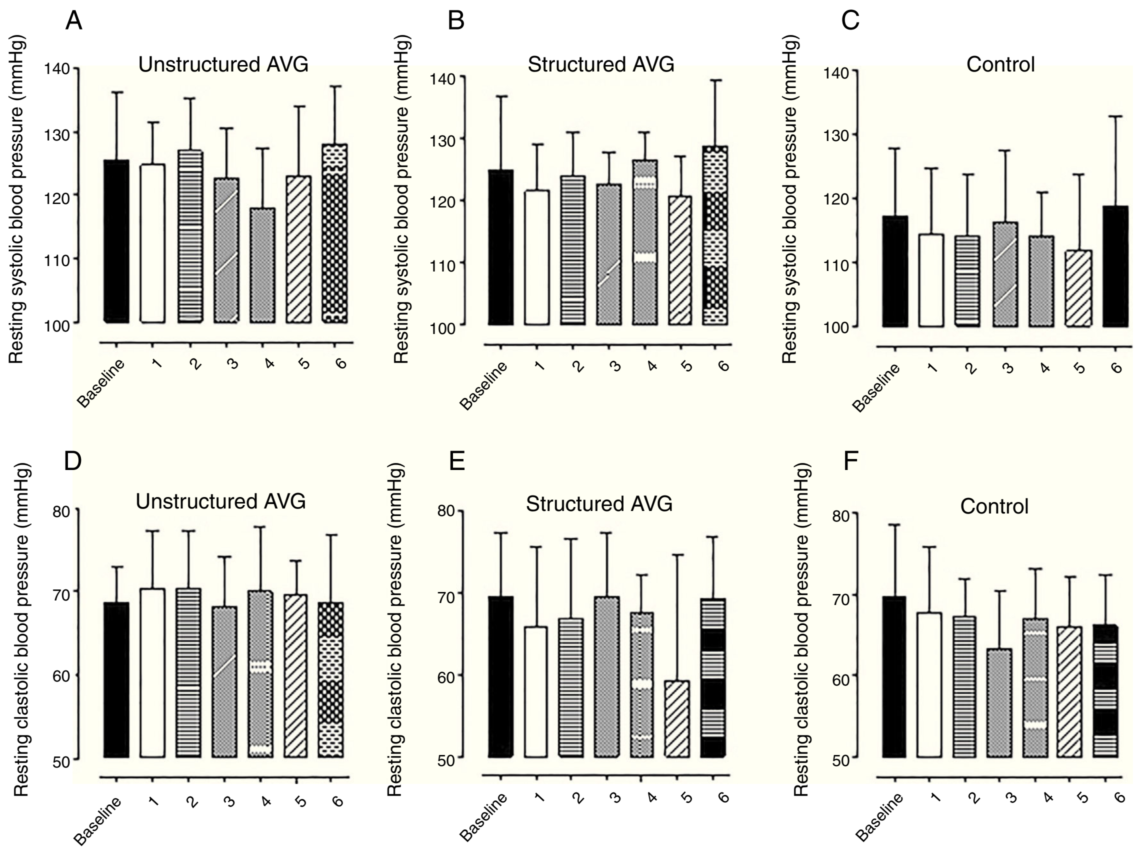

Figure 2 Resting systolic and diastolic blood pressure of the AVG's intervention and control group during the weeks. 1, 2, 3, 4, 5 and 6: Indicates the measurements of each week training.

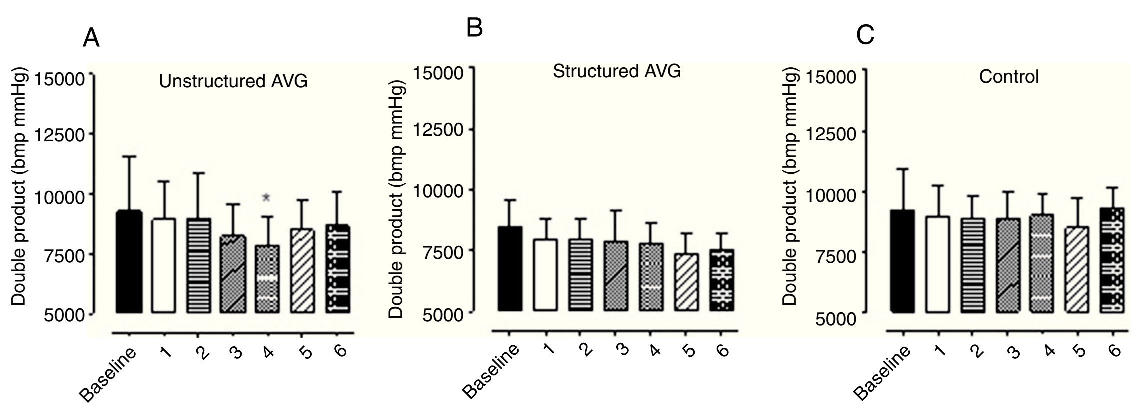

Figure 3 Resting double product of the AVG's intervention and control group during the weeks. 1, 2, 3, 4, 5 and 6: Indicates the measurements of each week training. *$p < 0.05$ in relation to baseline.

AVG practitioners at the fourth week, it not maintain until the end. Nevertheless, analyzing just in the end of the study, the structured AVG shown greater reductions in double product in comparison to unstructured and control group ($p = 0.018$), once they were with no difference among the groups in the baseline.

Knowing that a physical activity with cardiovascular characteristics should be use to promote hemodynamic benefits (Haskell et al., 2007) such as in the resting heart rate or systolic blood pressure because for example: the cardiac output, blood flow and better use of substrates into the recruitment of large muscle groups during the different types body movements which provide increase in cardiorespiratory stimulus (McArdle et al., 2003). This phenomenon may be seen by the use of the structured AVG as a form to exercise by reducing resting heart rate (variation of 14%), perhaps elevating the systolic volume (cardiac output = systolic volume vs heart rate). According to Maloney et al. (2008), using an unstructured AVG in 28 weeks, this changes were not observed with a variation of only 1.7% of heart rate by the end of the study. In this present study, the unstructured AVG present 8%, unfortunately with no different statistical changes. In another hand, the control group elevates the heart rate (−1% variation), showing the ''benefits'' of the AVGs intervention over this variable.

However, this cardiovascular impact was not sufficient to change the SBP and DBP in both AVGs. These results are according to some AVG studies with no statistical differences over these variables in relation to baseline (Kempf and Martin, 2013; Maloney et al., 2008), these studies also used normotensive people. A brief explanation should be the volunteers were normotensive and it has been seen that this population who was blood pressure close to normality border (<130/<80 mmHg); and distance from hypertension level 1: 140–159/90–99 mmHg (I Brazilian Hypertension Guidelines, 2013) that is very difficult to present hemodynamic blood pressure differences because of their normality function of this system (Cardoso et al., 2010).

Different from these results, Warburton et al. (2007), found differences in SBP using a structured AVG (GameBike) after 6-week intervention, in another hand, their subject had elevated SPB with 131 ± 7 mmHg (pre-hypertension 130–139/85–89 mmHg (I Brazilian Hypertension Guidelines, 2013), but reduced to 123 ± 6 mmHg (6% of variation). As the phenomenon explained before. Meanwhile, our study presents 11% of variation (pre: 125 ± 12 mmHg; post: 111 ± 47 mmHg) at the end of the intervention to structured AVG. It is known that a minimum reduction of 2 mmHg is clinically important because may promote 6% in the incidence of mortality from stroke and 4% for coronary artery disease (Chobanian et al., 2004). Thus, even with normotensive people use the structured AVG, they may promote cardiovascular SBP changes in percentage analysis. The same we cannot replicate to unstructured AVG, which have values similar to control group.

Specifically, in DBP analysis, the AVGs and control groups had no statistical and evident reductions. However, according to the literature this response is expect because with in a long-term DBP analysis, this variable should maintain or have a little decrease (Cardoso et al., 2010; McArdle et al., 2003). These were already seen by Maloney et al. (2008) in children (0.4% of variation), Kempf and Martin (2013) in elderly (0.6%) and now in the young adults (0.0% structured; 0.5% unstructured).

In addition, although the mechanisms involving cardiovascular variables were not investigated in this clinical trial, it is believed that many mechanisms may contribute to several change. It has been seen that changes in blood pressure is related by chronic exercise based in neuro-anatomical responses, as like reduction in the sympathetic activity and increased in parasympathetic activity, lowering blood pressure (Brum and Negrão, 2004). Furthermore, people who are physically inactive when starting an intervention respond positively to an increase in the capillaries and the oxygen consumption is elevated, favoring the decline in blood pressure (Monteiro and Sobral Filho, 2004; Cardoso et al., 2010; I Brazilian Hypertension Guidelines, 2013). The intervention with AVGs perhaps may not promote these mechanisms changes over normotensive young adults.

About the double product, only at the unstructured AVG in the 4th week can be seen significant reduction in DP returning with no statistical differences by 5th and 6th week. Although the structured AVG shown no statistical changes during the intervention, it is observed that after the end this intervention promote a reduction of 11%. Greater than unstructured with 2% of variation and control group that elevate this variable in the end (−2% variation). This decrease in the DP at rest is important result due to the relationship with cardiovascular problems and health, with these reductions is possible to reduce the cardiovascular risks which seems to be mediated to the decreased of adrenergic activity, the expected behavior by a chronic response (Forjaz et al., 1998; Gerage et al., 2007; Polito and Farinatti, 2003). To our knowledge, there is no other study at the literature to analyze DP in a long-term intervention with AVG. In this sense, this clinical trial results shows that training with these two AVGs is possible to provide only clinical benefit (with no statistical changes) by decreasing cardiovascular work reducing the risks and shown that is security intervention to use to exercise in a long-term analysis.

As a practical implication, the results of this study demonstrated for the first time, two AVGs, unstructured AVG (Kinect Sports Boxing; without prescription of training) and the specifically structured AVG (Nike Kinect Fitness; progressively) and their cardiovascular changes. Which the structured were better than unstructured due to principles of exercise prescription. Indicating that after 6 weeks of practice of this structured AVG, you must enter this activity a new stimulus of exercise prescription, as the frequency or duration, to acquire new benefits in RHR (only). That is possible on this type of AVG, once it has options inside the game to evolve the exercise. However, the authors truly recommend a physical education's attendance.

The limitations of this study were use a sample of only young adult males. Research has shown that men and women have different exercise motivations, attitudes toward video gaming (Graf et al., 2009) and cognitive functions (Teixeira-Arroyo et al., 2014). These differences may result in different exercise intensities during game play and subsequently different hemodynamic changes. It was used only a single structured and unstructured AVG and it is shown that not all game produce the same cardiovascular response (Brito-Gomes et al., 2014; Miyachi et al., 2010; Perrier-Melo et al., 2013). Other limitation maybe the time of 6 weeks to analyze these variables, perhaps another study should done this weekly methodology longer than 6 weeks. Furthermore, future research is needed to test the effectiveness of a broad range of structured and unstructured AVG to analyses the health cardiovascular benefits observed from others AVG and other populations such as women and hypertensive people.

Conclusions

The initial hypothesis were not confirm, just to structured AVG in the heart rate, in exactly 6 weeks. To both AVG interventions in SBP because their intervention were not enough to promote significant reductions in SBP, just to maintain the DBP during these 6 weeks of experiment. In addition, significant decrease observed on double product in the unstructured AVG practitioners only at the fourth week, but do not maintain until the end of the study. Another information, in the end of the study thestructured

AVG shown greater reductions (%) in comparison to unstructured and control group. However, in general, this types of active videogames unstructured (Boxing – Kinect sports) and Structured (Nike Kinect Fitness) do not promote real cardiovascular benefits in young normotensive adults. Future studies should analyze other populations with cardiovascular alterations such as hypertensive people.

Conflicts of interest

The authors declare no conflicts of interest.

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