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Immersive virtual reality is effective in improving the physical condition and quality of life of sedentary university students: A randomized clinical trial

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Abstract

Objective: To analyze the effects of immersive virtual reality training compared to conventional training on conditioning and quality of life of sedentary university students. Design: A randomized controlled trial with two intervention arms, concealed allocation, per protocol analysis, and blinded assessment. **Results:** In the intragroup analysis of physical conditioning using the shuttle walk test, the experimental group increased by 77.78 meters (95% CI, 25.3m to 130.1m) and the 6-minute walk test the control group improved by 89.92m (95% CI, 33.3m to 146.5m). Both groups improved in assessments of quality of life in the physical domain, with increases in scores of 65.49 (95% CI 56.48 to 74.49) and 63.79 (95% CI 51.36 to 76.22); in the psychological domain, an increase of 12.96 (95% CI 3.84 to 22.08) and 14.81 (95% CI 4.42 to 25.20); and, in the general assessment of quality of life, an increase of 88.75 (95% CI 59.9 to 117.6) and 81.84 (95% CI 36.5 to 127.1), in the experimental group and the control group, respectively. After two months, there was a maintenance of gains. Conclusion: Immersive virtual reality training and conventional training have the same effect on the improvement of physical conditioning and quality of life in sedentary university students.

Keywords: human physical conditioning. sedentary lifestyle. virtual reality exposure therapy

Introduction

Physical inactivity has a series of negative consequences for the health of the general population. A meta-analysis study revealed that 10-hours of sedentary behavior per day compared to 0-3 hours increased the risk of all-cause mortality by 34% [5]. Among university students, academic demands can result in a sedentary lifestyle. Therefore, this population is among those who least practice physical activity at the recommended intensity [13]. A study carried involving 2,200 European adolescents found an average sedentary time of 9 hours/day [19]. Motivation is a key factor for adhering to regular physical activity. Young university students tend to motivate themselves and adhere to some activity when there is the objective of doing it for their own good [10]. Therefore, it is necessary to investigate innovative and motivational alternatives to increase the adherence of this population to regular physical exercise [4]. Virtual reality has been widely discussed in the literature and can be an excellent alternative to involve young people in physical activities [15]. Many discussions are directed to exergames, which uses virtual reality in a non-immersive way. However, immersion in total virtual environments can generate more challenging modalities and a more pleasurable perception of physical effort, promoting greater engagement in the practice of the activity [25]. Immersive Virtual Reality (IVR) combines a series of components and systems to create a specific experience and immerse the participant in a simulated virtual world, a practice already used clinically in the treatment of psychological disorders [18] and as an alternative method for distracting patients' attention from pain in certain procedures [11]. However, there are still no studies with robust evidence, such as randomized clinical trials, evaluating the effectiveness of IVR in respect of physical conditioning and the quality of life of sedentary young people.

Thus, given the potential of IVR games to improve physical conditioning and strength, and the fact that they are programmed and designed to take into account the scientific recommendations that govern physical training [8], the aim of this study was to analyze the effect of IVR training compared to conventional training on conditioning and quality of life of sedentary university students in both the short and long term.

Method

Experimental Approach to the Problem

It was a randomized controlled trial with two intervention arms, concealed allocation, per protocol analysis and blinded assessment. Participants were recruited from the undergraduate course in Physiotherapy at the CESMAC University Center, in the city of Maceió, Alagoas, Brazil. Sedentary students from the physiotherapy course, who had not been taking part in any systematic regular physical activity for at least six months, were recruited through an announcement that was disseminated by email and through social media. All data collection was carried out at the Clinical School of Physiotherapy at the University Center. To verify the effectiveness of training through immersive virtual reality, participants were randomized into two groups, where the control group performed conventional training. For the evaluation of outcomes, we opted for the use of tests widely used in clinical practice and that provide reliable parameters.

Subjects

This study was approved by the Research Ethics Committee of the Centro Universitário Cesmac, Maceió, Alagoas Brazil, and registered in the Brazilian Registry of Clinical Trials, under number RBR-8d3qqn ([http://www.ensaiosclinicos.gov.br/rg/RBR-8d3qqn/](http://www ensaiosclinicos.gov.br/rg/RBR-8d3qqn/)). The publication of this study follows the recommendations of CONSORT 2010 [20].

Participants, allocation and randomization

All interested participants were invited to attend an initial meeting at which all the research procedures were explained. Those who were eligible and agreed to take part in the study signed a Free and Informed Consent Form. The inclusion criteria were: university students of both sexes, aged between 18 and 29, and who had been sedentary and not taking any exercise for at least six months; The exclusion criteria were: being unable to understand and respond to simple verbal commands; having heart disease; using walking aids; having a severe visual impairment that was not compensated by the use of corrective lenses; orthopedic disorders that resulted in movement limitation and use of lower limb prostheses.

Eligible participants were randomized into two groups, an experimental group (EG), which received a physical conditioning intervention using IVR, and a control group (CG) that received a conventional conditioning intervention.

The researcher assigned to generate the allocation sequence registered the participants included using numbered, opaque, sealed and stapled envelopes according to a randomly generated sequence. The randomization sequence was generated in two blocks in a random sequence generator, using the website [random.org](https://www.random.org) (<https://www.random.org>). This researcher was not involved in the other stages of the research.

The research participants were then assessed by a group of evaluators who carried out the process without knowing the participants' allocation. The research participants were then sent to the group of researchers who carried out the

interventions, who, only at that time, received the sealed envelopes from the researcher responsible for concealing the allocation, which determined which group each participant would be in.

Blinding

The researchers responsible for the evaluations (initial, final and follow-up evaluation) and the researcher responsible for the statistical analysis of the data were kept blind to the allocation.

Procedures

Interventions

The intervention protocols of the two groups were implemented following the recommendations of the American College of Sports Medicine (2011), which in its guidelines for prescribing cardiorespiratory exercise, recommends: 1) 20 to 60 minutes of vigorous intensity exercise (three days a week); 2) A gradual progression in the duration, frequency and intensity of exercise for better adherence and less risk of injury; 3) Individuals unable to meet the recommended minimum volume can benefit from the practice of other activities [9].

Description of the Experimental Group Protocol

The intervention protocol with the immersive virtual reality group was applied using the OCULUS RIFT (Consumer Edition, Facebook, United States), a device that gives users the feeling of being immersed in the virtual environment. It is a head-mounted display (HMD) capable of detecting changes in the orientation of the head, measuring magnetic fields, making possible the absolute orientation and quantification of movement acceleration, through the use of three sensors, respectively, a gyroscope, magnetometer and accelerometer.

The BoxVR game, which is part of the Oculus Rift library, was chosen to be used in the program. Before the start of the sessions, the study participants went through a familiarization session with the virtual reality resource. BoxVR requires the player to combine movements that involve alternating punches, in different directions, jumps and squats. All activity is performed with a musical background. The intensity, quantity and speed of the movements in the game were increased during the training program, depending on the progression achieved by the individual in the game

Description of the Control Group Protocol

The control group underwent a conventional conditioning training, making punching movements with the arms, jumps and squats, accompanied by rhythmic music. The sequence of exercises was similar to that of the experimental group. The intensity, quantity and speed of the strokes, jumps and squats was increased during the training program, depending on the improvement in physical condition of the research participants.

Characterization of interventions

Both groups performed 24 individual intervention sessions, twice a week and with a duration of 50 minutes per session. Before, during and after each intervention session, vital signs were monitored. During the entire intervention, the researchers stayed with each participant, instructing, assisting and guiding them in the execution of each activity.

Outcome measures

Participants were re-assessed immediately after treatment

(one day after the last session), as well as at two months after that reassessment (follow up).

Primary outcome

The primary end point was functional improvement for fitness, measured using the Shuttle Walk Test (SWT) and the 6-minute Walk Test (6MWT).

The SWT was carried out following the original recommendations of its developers^[21] over a distance of 10m, indicated by two cones 0.5m from the ends of the course. The start of the course was indicated by a sound stimulus of a triple bleep. Thereafter, the volunteer was instructed to follow the course, their pace being guided by a single bleep, at which point the subject was told they should be at the end of the course and turning round to come back. The total test consists of 12 levels lasting one minute each, with the speed requirement increasing with each level.

The test was interrupted in the presence of symptoms such as malaise, nausea, severe dyspnea, extreme fatigue or chest pain or when the patient was 0.5 m away from the cone at the moment of the sound stimulus. Heart rate (HR), oxygen saturation (SpO₂), blood pressure (BP) and Borg scale for dyspnea and fatigue were recorded before and immediately after the end of the test, with HR and SpO₂ being recorded every minute.

The 6MWT followed the recommendations of the American Thoracic Society^[1] and was carried out in a 30m long flat corridor, with a mark for each meter. The volunteer received verbal commands and standardized phrases of encouragement every minute, and was instructed to walk as fast as possible for six minutes. They were allowed to reduce their pace or stop, but the timer was not stopped until the six minutes had elapsed.

Secondary outcomes

Quality of life was assessed using the World Health

Organization (WHO) - Whoqol-Bref questionnaire. This questionnaire consists of 26 questions, 2 general and the remaining 24, divided into 4 domains: physical, psychological, social relations and the environment. The results of this questionnaire generate a scale from zero to one hundred, with the higher the average score, the better the quality of life^[27].

Calculation of sample size

To guarantee statistical power in order to find an increase of 120 meters^[22] in the 6MWT test in the experimental group compared to the control group, with a standard deviation of 80, a test power of 80% and an alpha value of 5%, it was calculated that it would be necessary to have nine individuals in each group, making a total of 18 individuals. The calculation was performed using the Gpower v 3.1.9.2 software (Dusseldorf Universitat, Dusseldorf, Germany).

Statistical analysis

Continuous variables are presented as means, standard deviation and confidence intervals, while categorical variables are presented as relative and absolute frequencies. The interaction between the group and the results of the physical tests and quality of life instrument was performed using a mixed ANOVA. For all analyses, an alpha value of 5% and the statistical program SPSS v21.0 (IBM Inc, Armonk, NY, USA) were used.

Results

Flow of participants through the study

A total of 42 sedentary university students were assessed for eligibility, of which 21 were included in the randomization process, being divided into two groups. A diagram of patient retention and randomization throughout the study is shown in Figure 1.

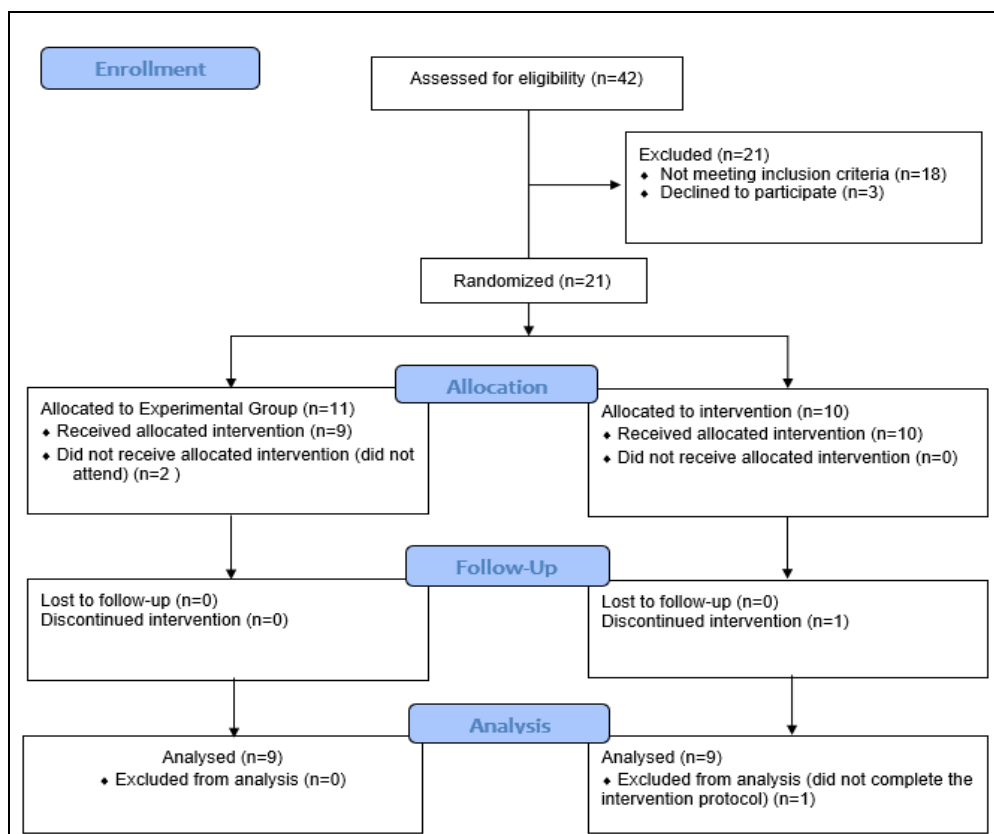


Fig 1: Design and flow of participants through the trial.

Baseline characteristics of the participants

The study sample consisted of 18 sedentary university students divided into a control group (n = 9) and an experimental group (n = 9). Table 1 shows that there were no

statistically significant differences between the two groups in terms of sociodemographic characteristics, lifestyle and functional level related to physical condition.

Table 1: Baseline characteristics of the participants (n = 18).

Variables	Groups				P-value
	Conventional (n = 9)		Experimental (n = 9)		
	Mean	SD	Mean	SD	
Age (years)	24.4	2.2	21.7	1.4	0.71
BMI (kg / m ²)	23.4	4.2	24.7	5.6	0.60
Initial 6MWT	557.2	99.8	496.7	91.6	0.19
Initial shuttle	418.8	70.3	420.6	90.7	0.96
	N	%	N	%	
Sex					0.62
Male	3	33.3	4	44.4	
Female	6	66.7	5	55.6	
Consume alcohol					0.99
No	4	44.4	4	44.4	
Yes	5	55.6	5	55.6	
Smoker					0.99
No	9	100.0	8	88.9	
Yes	0	0.0	1	11.1	
Self-reported disease					0.99
No	8	88.9	9	100.0	
Yes	1	11.1	0	0.0	

Effect of the intervention

Table 2 shows the intra and intergroup comparisons for each test used in the evaluations. There was no statistically significant difference between the two groups for any of the assessed outcomes. However, in respect of quality of life in the intragroup analysis both groups showed significant results

in the Physical and Psychological domains, and in total quality of life scores. In the 6-minute Walk Test, only the experimental group showed a statistically significant improvement, while in the Shuttle Walk Test, only the control group showed a statistically significant improvement (Table 2).

Table 2: Mean (CI 95%) for outcomes at the pre-intervention, post-intervention and at follow-up for each group, and between-group differences.

Variables	Groups				Effect Size	CI 95%
	Conventional (n = 9)		Experimental (n = 9)			
	Mean	CI 95%	Mean	CI 95%		
PHYS Pre	11.49 ^a	10.74; 12.23	12.0 ^a	11.01; 12.98		
PHYS Post	76.98 ^b	67.97; 85.99	75.79 ^b	63.38; 88.20		
PHYS Follow-up	72.62 ^b	66.63; 78.60	75.79 ^b	66.60; 84.97		
Pre-Post Change	65.49 [*]	56.48; 74.49	63.79 [*]	51.36; 76.22	1.69	-12.4; 15.8
Post-Follow-up Change	-4.36	-9.07; 0.34	0.00	-7.13; 7.13	-4.36	-12.2; 3.4
PSYCH Pre	63.88 ^a	58.57; 69.20	58.33 ^a	50.82; 65.84		
PSYCH Post	76.85 ^b	67.91; 85.78	73.14 ^b	63.52; 82.77		
PSYCH Follow-up	73.15 ^b	69.90; 76.39	71.76 ^b	65.19; 78.31		
Pre-Post Change	12.96 [*]	3.84; 22.08	14.81 [*]	4.42; 25.20	-1.85	-14.5; 10.8
Post-Follow-up Change	-3.70	-12.39; 4.98	-1.38	-11.12; 8.35	-2.31	-14.3; 9.6
Social Pre	72.22	65.06; 79.38	72.22	57.19; 87.24		
Social Post	75.92	59.45; 92.39	71.29	56.58; 86.01		
Social Follow-up	73.15	65.44; 80.84	73.15	65.44; 80.84		
Pre-Post Change	3.70	-12.97; 20.38	-0.92	-14.30; 12.45	4.6	-15.0; 24.2
Post-Follow-up Change	-2.77	-20.61; 15.05	1.85	-10.03; 13.74	-4.6	-24.3; 15.7
ENVIR Pre	59.02	48.59; 69.45	56.59	48.50; 64.69		
ENVIR Post	65.62	58.41; 72.83	60.76	48.39; 73.13		
ENVIR Follow-up	63.19	57.85; 68.53	62.50	52.16; 72.83		
Pre-Post Change	6.59	-7.88; 21.08	4.16	-12.47; 20.80	2.4	-17.8; 22.7
Post-Follow-up Change	-2.43	-9.81; 4.95	1.73	-5.87; 9.34	-4.1	-13.9; 5.5
Total Pre	206.63 ^a	189.2; 224.0	199.15 ^a	171.1; 227.1		
Total Post	295.38 ^b	267.1; 323.6	281.00 ^b	237.4; 324.5		
Total Follow-up	282.11 ^b	267.9; 296.3	283.20 ^b	257.7; 308.6		
Pre-Post Change	88.75 [*]	59.9; 117.6	81.84 [*]	36.5; 127.1	6.9	-42.4; 56.3
Post-Follow-up Change	-13.2	-32.4; 5.9	2.19	-26.6; 31.0	-15.4	-47.2; 16.3
TC6 Pre	557.2	480.5; 633.9	496.7 ^a	426.5; 566.9		
TC6 Post	637.06	607.5; 666.5	586.66 ^b	514.8; 658.4		
TC6 Follow-up	591.77	531.5; 652.0	588.65 ^b	547.5; 629.7		
Pre-Post Change	79.82	-5.32; 164.9	89.92 [*]	33.3; 146.5	-10.1	-104.0; 83.8
Post-Follow-up Change	-45.29	-96.75; 6.16	1.99	-45.04; 49.03	-47.2	-111.3; 16.8

Shuttle Pre	418.8 ^a	364.4; 472.8	420.6	350.8; 490.3		
Shuttle Post	496.60 ^b	424.7; 568.4	477.64	397.6; 557.6		
Shuttle Follow-up	499.79 ^b	420.2; 579.3	464.82	390.8; 538.7		
Pre-Post Change	77.78 [*]	25.3; 130.1	57.02	-9.25; 123.3	20.7	-56.9; 98.4
Post-Follow-up Change	3.19	-33.7; 40.1	-12.82	-56.7; 31.1	16.0	-36.7; 68.7

* Presence of significant difference;

^{a,b} Different letters in the same column indicate the presence of a significant difference.

CI: Confidence Interval

Participants in the experimental group and the control group received an average of 22.2 (SD 2.4) and 23.1 (SD 2.2) sessions, respectively. The average duration of the sessions was 50 minutes. About half of the participants attended more than 80% of the program sessions. No serious adverse events were reported.

Discussion

The study analyzed the effect of physical conditioning training through immersive virtual reality on sedentary young university students compared to conventional training on functional capacity and quality of life, after 24 intervention sessions. No difference was found between the groups, however, both were able to improve their functional level in respect of physical conditioning, as well as quality of life.

The scientific literature already highlights the use of virtual reality, through exergames, to provide digital options to motivate sedentary individuals and children at risk of obesity and diabetes to practice physical activity [17]. The structural elements of the games encourage the players to spend more time trying to increase their scores and meet the challenges of the different levels of the games, thereby increasing their energy expenditure, and improving their physical condition [2].

However, IVR is still little explored in respect of various health-related outcomes, including the implementation of regular physical activity. The study presented here was able to reveal that this resource proved to be as effective as conventional training. The gains found allow us to confirm the hypothesis that the practice of physical activity through IVR allows physiological responses to exercise that are similar to those that would take place if the activity were performed in a real environment [24].

In addition to increasing interest and motivation in respect of physical activity [25], total immersion, because of its similarity to reality stimulates motor responses like those produced in the real world, but only through visual exploration [23]. That is, the interaction in real time creates the illusion of body ownership [3], which leads to better quality in the execution of the movements.

Due to its motivational character and the fact that it is perceived as a leisure activity, IVR has the potential to increase adherence to the practice of physical activity for those who do not adhere to conventional activities, and may even replace some commonly practiced physical exercises performed in the traditional way [6]. This was shown in the study by Liu *et al.* [14], which compared conventional practice, immersive and non-immersive virtual reality, and concluded that IVR presented a greater degree of involvement and motivation among young university students. Total immersion is then the primary factor that differentiates this resource from other types of physical activity practices, and may explain the improvement in physical condition and quality of life outcomes in the experimental group observed in this study.

Another important factor which contributed to the significant improvement in the conditioning of the sedentary young people using IVR was the progression of the levels in the

boxing game, as well as the variety of physical stimuli that were available, including constant and progressive muscle stimulus. Advancing through different levels with greater muscular demands promotes greater the energy expenditure [26], and although IVR is similar to exergames in this respect, it has the advantage of allowing total immersion, which, as previously mentioned, generates greater engagement, as the realism of the game promotes more involvement in the activity performed.

Thus, the challenging virtual environments and the interaction with the tasks required by the games, such as those related to boxing, condition the improvement of motor skills [16], improvements which were found to be maintained even two months after the end of the intervention, as observed in the follow-up evaluation.

Another factor that must be considered in the virtual environment is distraction. During total immersion the user is more engaged with the activity when compared to conventional training [7] causing the players to spend more time practicing physical activity in the virtual environments than in real ones [12]. In this scenario, the fun aspects of the game contribute to the users paying less attention to the negative aspects inherent in performing exercise.

Practical Applications

Immersive virtual reality proved to be as effective as conventional therapy for improving physical conditioning and quality of life for sedentary university students. Thus, the data presented here support the use of IVR in the practice of physical activity, showing similar results to conventional physical exercise in respect of improving functionality through better physical condition, and a consequent positive impact on quality of life. IVR can therefore be a promising form of exercise for those who have difficulty finding the motivation to engage and adhere to conventional exercise practices.

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Conflict Of Interest Statement

The Authors declares that there is no conflict of interest

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