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Age and Ageing 2021; 1–4
doi: 10.1093/ageing/afab040

SHORT REPORT

Cycle more with virtual reality: a proof of concept study in an institutionalised able-bodied geriatric population

Gilles Loggia[1], Antoine Gauthier[2], Fabrice Lemiere[2], Joffrey Drigny[3], Antoine Desvergee[4], Pascale Leconte[2], Alexis Ruet[5]

[1]Normandie Univ, UNICAEN, CHU de Caen Normandie, Service de Gériatrie, 14000 Caen, France
[2] Normandie Univ, UNICAEN, Inserm U1075, COMETE, GIP Cyceron, 14000 Caen, France
[3]Normandie Univ, UNICAEN, CHU de Caen Normandie, Service de Médecine Physique et de Réadaptation, Inserm U1075, COMETE, GIP Cyceron, 14000 Caen, France
[4]Normandie Univ, UNICAEN, CHU de Caen Normandie, Service de Médecine Physique et de Réadaptation, 14000 Caen, France
[5]Normandie Univ, UNICAEN, CHU de Caen Normandie, Service de Médecine Physique et de Réadaptation, INSERM U1018 UPS UVSQ, INSERM EPHE U1077, 14000 Caen, France

Address correspondence to: Alexis Ruet. Tel.: +33 02 31 06 47 21; Fax: +33 02 31 06 50 47. Email: ruet-a@chu-caen.fr

Abstract

Background/Objectives: Physical activity (PA) has significant benefits for older adults. However, the recommended PA is rarely achieved in nursing homes. In this proof of concept study, we assessed whether virtual reality (VR) could help to increase spontaneous PA during a stationary cycling session.
Design: Prospective crossover proof of concept study.
Setting: Nursing home.
Participants: Twelve participants (10 men) aged 63–88, able-bodied but with moderate cognitive impairment.
Intervention: TWO stationary cycling sessions with and without VR.
Measurements: Cycling distance, pedalling duration, average speed, mean pedalling cadence and the modified Borg rating of perceived exertion scale.
Results: Cycling distance and duration were significantly higher in the VR condition. Most participants would rather repeat cycling sessions with VR than without.
Conclusion: The use of VR seems feasible to help achieve PA recommendations for able-bodied people living in nursing homes, even with moderate cognitive impairments.

Keywords: older people , nursing home , exercise, virtual reality

Key Points

- This work highlights the potential usefulness of VR to promote PA among institutionalised older people
- Cycling in a virtual environment is appreciated by institutionalised seniors with cognitive impairments.
- VR devices are increasingly widespread, affordable and can be well accepted by most in this population.

Introduction

Physical activity (PA) has significant health benefits for older adults, preventing cognitive decline, extending years of active independent living, reducing the risk of disability and improving quality of life [1].

According to the World Health Organization's recommendations, people aged 65 years or older should practise weekly at least 150 minutes of moderate-intensity aerobic PA or at least 75 minutes of vigorous-intensity aerobic PA, or an equivalent combination of moderate and vigorous PA associated with strength exercises and stretching/coordination exercises, to maintain physical and mental well-being and reduce falls [2]. Conventional PA programmes usually suffer from low participation and engagement of older people, especially in nursing homes, which can be explained by the lack of motivation and the fear of injury. This last decade, the use of virtual reality (VR) has emerged in the field of falls prevention for older adults [3]. In addition to improving balance and mobility, these tools offer the potential advantage of being more fun and engaging than traditional types of PA. However, the effectiveness of VR tools has rarely been compared with conventional approaches of PA in older adults [4].

The aim of this interventional, prospective, crossover proof of concept study was to test the effect of a VR device on the duration and distance travelled during a stationary cycling session among institutionalised older people.

Methods

The main inclusion criteria were age over 65 and ability to cycle. The main exclusion criteria were unstable heart disease, normal to severe limitation of activity according to the New York Heart Association (i.e. classification III or IV), severe cognitive or physical impairment with inability to follow simple instructions (follow investigator, ride on the ergometric bicycles, pedal) and severe visual disturbance.

All the participants performed 3 cycling conditions during a familiarisation session, (i) on a cycling device with chair and backrest (Cycleo, COTTOS medical) without VR; (ii) on the same cycling device with chair back and VR; and (iii) on a classic ergometric bicycle without chair back (Kettler E3). Participants were shown how to get on the bike, how to pedal as well as how to navigate in the virtual environment. The third condition was proposed to assess how participants feel about the devices (i.e. seated on a saddle versus seated on a chair with a backrest). The VR environment consisted of projecting a cycling course on a large screen in front of the participant on which he would pedal and steer on the handlebars. The VE was designed as a countryside where participants had to cycle along a gravel road.

Then, participants performed two cycling sessions according to conditions a and b (i.e. on a cycling device with chair and backrest with and without VR). These two sessions were performed in a randomised order with an interval of 1–7 days between sessions. No instructions were given during the sessions in order to measure the spontaneous production and avoid influencing their efforts. Sessions where limited to 30 min of cycling. Cycling duration, distance and speed were collected directly by the cycling device. The modified Borg rating of perceived exertion was measured at the end of each session. A pedal-based metre (Garmin Vector 2) associated with a Garmin Edge 520 for the control and the display of the data has been adapted on the Cycleo to measure the pedalling cadence. The cycling devices have been set to the lowest resistance.

The primary outcome was the cycling distance measured at each session. The secondary outcomes included the pedalling duration, cadence, speed and the modified Borg rating of perceived exertion scale [5]. In the end, participants were asked which condition between 'classic ergometric bicycle', 'cycling device with VR' or 'cycling device without VR' they would prefer for future exercise session.

This study was performed in accordance with the Declaration of Helsinki. A national ethics committee granted approval (CERSTAPS Number 2019-26-04-33). The investigator gave oral and written information on the study to each participant, and informed written consent was then obtained. We retrospectively registered the study on the clinical trials (NCT03834545).

Qualitative data were expressed as absolute and relative frequencies, and quantitative data as mean and standard deviation or as median and interquartile range (IQR) if not. The Shapiro–Wilk test was used to assess for normality. Different linear mixed models were computed when applicable with cycling distance, time spent pedalling, average speed, mean pedalling cadence, and Borg scale score as dependent variables. The independent variable was the conditions of cycling sessions (i.e. with or without VE), with fixed effects and participants had random effects. When validity conditions for models were not met, a paired Student's t-test was used or a Wilcoxon ranked signed test if variables were not normally distributed.

Results

Twelve older adults (10 men) were included from a nursing home and participated to this study. The mean age of the participants was 75.3 ± 8.5 years, their mean weight was 79.8 ± 11.8 kg, and their mean height was 169.2 ± 8.8 cm. Two participants had a normal weight (body mass index [BMI] 18.5 to <25, seven were overweighted (BMI 25 to <30), two were obese (BMI ≥ 30). Their mean mini-mental state examination scores was 14 ± 3.6, and their mean activities of daily living score was 6 ± 0.8 [6]. Six additional residents volunteered at first but a woman finally refused the familiarisation session without giving explicit reason, three women and a man were not able to sit on the classic ergometric bicycle, and a woman could not climb on both cycling devices. They were excluded from the analysis.

The main results of the study are summarised in Table 1. The cycling distance was significantly higher on cycling device with VR than on cycling device without VR ($t = -3.18$, $P < 0.01$). In 10 participants out of 12, the distance covered was longer with VR than without. Similarly, the cycling duration was significantly longer on cycling device with VR than on cycling device without VR ($t = -3.2$, $P < 0.013$) (Figure 1). However, pedalling cadence did not differ between cycling device with VR and cycling device without VR ($t = 0.6$, $P = 0.5$) nor Borg score (paired Wilcoxon ranked sign test $V = 14.5$, P value $= 0.36$). The cycling speed did not differ between these

Table 1. Main results of participants according cycling device

	Cycling device without VR	Cycling device with VR	*P* value
Cycling distance (metres)[a]	7100.1 [4841.3]	10,187.9 [3233.4]	0.01
Cycling duration (minutes)[b]	19.9 [19]	26.8 [9.5]	0.03
Mean cycling speed (m/s)[b]	6.2 [4.3]	7.1 [0.9]	0.12
Mean pedalling cadence(RPM)[a]	47.5 [9.1]	45.9 [12.4]	0.56
Borg scale score[b]	2 [1]	2.5 [1]	0.28

RPM: revolution per minute [a]Mean [standard deviation] [b]Median [IQR]

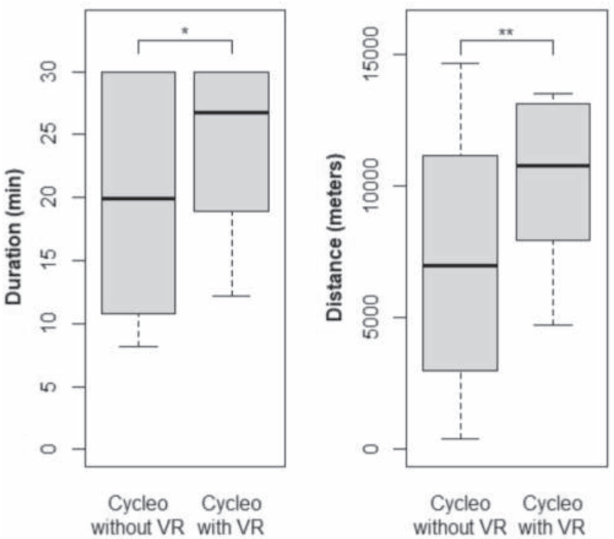

Figure 1. Effect of VR on cycling duration and distance. $^{*}P < 0.05$; $^{**}P < 0.01$.

two conditions either (V = 23, *P* value = 0.2334). Eight participants (67%) declared they would prefer practising exercise on cycling device with VR, two (17%) chose cycling device without VR, one (8%) chose the classic ergometric bicycle and one (8%) answered 'none'. No participants reported any side effect on the various conditions.

Discussion

This study showed that our samples of able-bodied nursing home residents with moderate cognitive impairment were willing to cycle on an exercise bike and that despite their cognitive impairment they cycled further, for a longer period with the VR set up and preferred this one.

We can assume that VR might be effective in promoting regular PA adherence and increasing the total amount of PA in this institutionalised geriatric population, because of its recreational or motivational effect. In addition, Borg's scale score did not differ between conditions, suggesting that participants had the same perception of exercise even for higher levels of physical effort. These results agreed with those of Bruun-Pedersen *et al*. [7], who suggested that VR provides a sense of purpose during stationary cycling. In their study as in our, they showed that older adults were enthusiastic about VR technology and wanted to continue using the VR device rather than practise conventional PA without VR.

One would think that tolerance to VR may be a limit in this older adult population, but some authors confirmed the general comfort, tolerability and minor or no side effects of VR [8,9]. Although these new technologies are frequently perceived as unsuitable for this population, this proof of concept study was easily accepted by the participants and showed significant effects of VR on duration and distance of cycling. This finding suggests that VR could be used to promote PA even in people with cognitive decline.

The main limitation of the present study was the small size of the sample. A larger sample and a more heterogeneous population would be necessary for future studies. Surprisingly, participants were fairly independent for institutionalised people although not a criterion for inclusion. The ability to use the cycling devices, which were required to participate in the study, excluded dependent residents. Despite a good acceptance of VR, a better assessment of the motion sickness will be necessary in the future to confirm the absence of adverse effects. Future studies should examine whether benefits and the attraction for VR persist in repeated PA sessions or not.

Older adults seem more inclined to perceive VR as useful, easy to use and an enjoyable experience. They are willing to use VR training at home to have fun and stay active without being limited by external factors, such as weather condition, or lack of partners. Indeed, this innovative tool might help older people to maintain their physical condition, and to monitor their performance, even with cognitive impairments [10].

Declaration of Conflicts of Interest: None.

Declaration of Sources of Funding: None.

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Received 28 November 2020; editorial decision 21 January 2021