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Effect Of Exergaming On Core Muscle Endurance And Enjoyment In Young Adults: A Pilot Study

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ABSTRACT

Background: The core provides a foundation for movement in the periphery and comprises muscles that stabilize central and peripheral major joints. Strength and endurance are both necessary for core stability, but poor endurance of core muscle is a major risk factor for low back pain in a healthy person. Despite traditional methods of improving core stability, poor adherence to exercise is a significant problem in young adults. In the 21st century, "exergame" or exercise-based video gaming is an attractive option for improving physical function. So, the present study aims to evaluate the effect of exergame on core muscle endurance and enjoyment of young adults.

Methods: Quasi-experimental research was used. Male and female participants (n=30,15 in the Intervention group and 15 in the Control group) were recruited. The intervention group was given training with Nintendo® Ring Fit Adventure (RFA) exergame three times a week for six weeks. The control group received a general core endurance training program with the same duration and frequency. The McGill endurance test assessed core muscle endurance. Enjoyment of exergame was assessed using an Exergame Enjoyment Questionnaire.

Results: The study showed that in both groups, there was a significant increase in endurance time ($p<0.05$). Between-group analysis showed that the intervention group had a highly significant difference in endurance time compared to the control group ($p<0.01$).

Conclusion: RFA exergame can offer more enjoyment while playing and improve young adults' core muscle endurance. Exergames can be an exciting way of improving physical function in the technological era.

Keywords: Central core, endurance, video game, pleasure, adults, technology.

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INTRODUCTION

The core is often termed the "powerhouse" of the body, the basis of all limb movements and the functioning axis of the kinetic chain [1]. The core is represented as an anatomical box that consists of 29 pairs of muscles. At a high level, this anatomical box is made up of the top (Diaphragm), bottom (Pelvic floor and hip girdle), front (Abdominals), and back (Paraspinals and gluteal) [2].

The combined action of all these muscles provides stability to the spine and pelvis while doing different functional activities. From literature, core stability is defined as "the ability to control the position and motion of the trunk over the pelvis and leg to allow optimum production, transfer, and control of force and motion to the terminal segment in integrated kinetic chain activities" [3].

Core stability is vital for different functional movements, and lack of activity in muscle initiation could lead to injury. Therefore, various core exercise programs are necessary to discuss the effectiveness of these muscle groups [4]. These core muscle exercises prevent injury to the central body axis and peripheral regions such as the shoulders, knees, and ankles [5].

For better balance and stability, different core muscle exercises related to strength and endurance are available. Although core muscle strengthening exercises are necessary for activity and sports, core muscle endurance also has a unique role in maintaining spinal stability during prolonged physical activity [4].

Muscle endurance is "the ability of a muscle to maintain a posture or perform movement" [6]. Poor endurance and fatigue of trunk muscles will predispose the trunk to risk injury and low back pain [7]. Unfortunately, despite numerous traditional methods to improve core muscle endurance, young adults have very little adherence to participating in such programs. In this technological era, virtual reality can be a substitute for young adults. In scientific literature, "exergaming" is used for this gaming-based virtual reality training [8].

Exergaming may improve conditions like childhood obesity, neurodegenerative conditions, and neck and back pain [9]. Exergaming can improve physical and motor skills; however, few studies show its effect on healthy adults [8]. Most of the literature on exergaming has used simple games to improve motor and physical function. Still, a new game by Nintendo® was released worldwide on October 18, 2019, focusing on fitness levels through exercise. It is an exercising action role-playing game that comes with proper muscle set exercise with warm up and cool down protocol. Thus, there is a need to examine the effect of this new exergame on any fitness component. And due to low adherence problems in young adults, this study would like to focus on examining enjoyment levels so adherence to exercise can be improved in the future. Also, a handful number of studies are present in India on exergaming. Therefore, the most available literature is from a different population.

To date, no studies have been noted on the effect of exergaming on young adults' core muscle endurance in India. So, the aim of the present study is "to investigate the effect of Nintendo® Ring Fit Adventure exergame on core muscle endurance and enjoyment of young adults."

MATERIALS AND METHODS

A quantitative research approach was used for this study. First, a quasi-experimental (pre-test, post-test control group) design was selected. This study was conducted from June to October 2021. Second, OpenEpi software was used to calculate the sample size based on previous literature for this study. Third, a nonprobability convenient sampling technique was used to select 30 young adults ("participants") from Ahmedabad, Gujarat, India (15 in the intervention group and 15 in the control group). Finally, informed written consent was taken from all the participants.

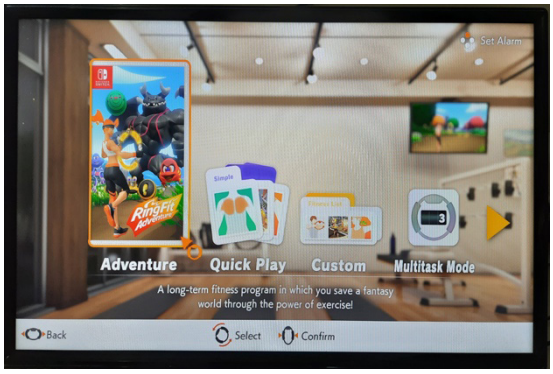
Ethical clearance: Ethical clearance was taken from the Institutional Ethical Committee of Nootan College of Physiotherapy, Gujarat, India, with reference no. NCP/241-A/2020-21. Young adults within the age group 18-30 years, including 15 males and 15 females willing to participate in the study, were included. Young adults with any recent illness or injury, cardiovascular or neurological disorder, history of low back pain in the last six months, resistance training, or any other type of gym training in the last six months were excluded from this study.

Intervention Group:

Ring Fit Adventure ("RFA") - a fitness role-playing free-to-use game, playable on Nintendo® Switch gaming console, was used as an exergame. RFA included a ring-shaped controller ("Ring-Con") and a leg strap holding Nintendo Switch's Joy-Con controllers. These were used with the game to respond to participants' real-world movements and to turn them into in-game actions. As part of this study, each exercise session was about 40 minutes long, consisting of 5 minutes warm-up, 30 minutes gameplay, and 5 minutes cooldown.

The warm-up session consisted of jogging and stretching. Low-intensity jogging was completed by selecting one available jogging tract in the exergame. Then, stretching of major muscle groups like back extensor, trunk flexors, quadriceps, hamstring, calf, biceps, triceps, and pectoralis major was completed, corresponding to the muscle groups being worked as part of gameplay.

RFA game has several modes, each comprising sets of exercises. This study included adventure mode, rhythm mode, minigames, and sets. [Fig-1]



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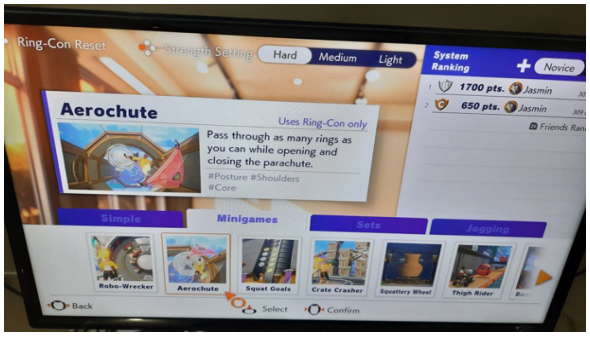

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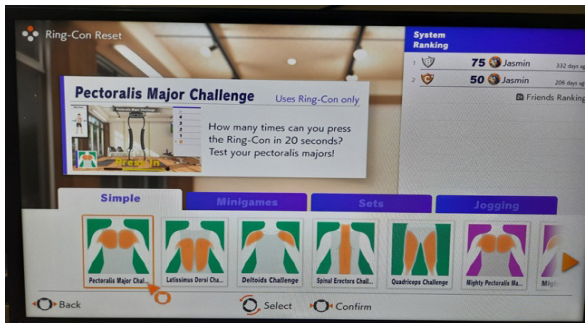

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[Fig-1] showing images for Nintendo® Ring Fit Adventure.*(a)-different modes (b)adventure mode (c) minigame section (d) jogging (e)special muscle set (f) ring shaped and joy con controller, Nintendo switch.

Adventure mode is a role-playing game where the participants take the role of a young athlete and defeat monsters. While moving along a fixed path by running in place, the participants perform one of about thirty different exercises to progress through stages.

Rhythm mode allows participants to perform exercises along with soundtrack of the game.

Minigames allow participants to perform a single exercise repeatedly for about a minute and challenge their previous record.

Sets allow participants to perform specific exercises, assisted by the game, but without the gamification elements.

Exercise Protocol:

As part of adventure mode, special core-related exercises were selected during gameplay. [Fig-2] Rhythm mode included exercises targeting core-upper or core-lower limbs. From minigames, exercises that use core muscles were included like "crate crasher," "core crushing," "bank balance," "smack back," and "gluting gallery." Various sets are provided in the game, from which core set, abs set, waist set, chest set, back set, and flexibility set were selected. In addition, a few special muscle sets like latissimus dorsi, erector spine, endless latissimus dorsi, and endless erector spine were also included. The exercise intensity was set according to the participants' wishes or based on the game's suggestions. The exercise was performed three times a week for six weeks. By combining these different modes, a self-made protocol was used for training consisting of exercises mainly targeting core muscles. After every two weeks, the exercise protocol was changed. Each exergame score was recorded for reference and for motivating participants to improve upon that score in their next session. The cooldown session was similar to the warm-up session.

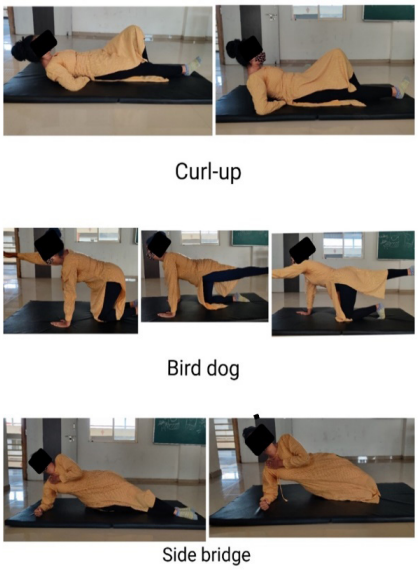
[Fig-2] Showing images of participants playing Nintendo® Ring Fit Adventure.

Control Group:

Warm-up and cooldown protocols were the same as the intervention group, except marching in place was done for low-intensity jogging.

The exercise was performed three times a week for six weeks. Core endurance general training was used mainly with curl-up, side-bridge, and bird-dog exercises. All participants were taught the "bracing" maneuver and were

asked to use it with all endurance training exercises. **For the curl-up exercise**, during the first three weeks, hands were placed under the lower back with elbows on the floor, and for the last three weeks, this exercise was done with the elbows raised off the floor. **For the side-bridge exercise**, the fulcrum was kept at knees and elbow during the first three weeks, and for the last three weeks, the fulcrum was kept at the feet and elbow. **For the bird-dog exercise**, during the first three weeks, arms and legs were raised off the floor separately, and for the last three weeks, arms and legs were raised off the floor simultaneously. [Fig-2]

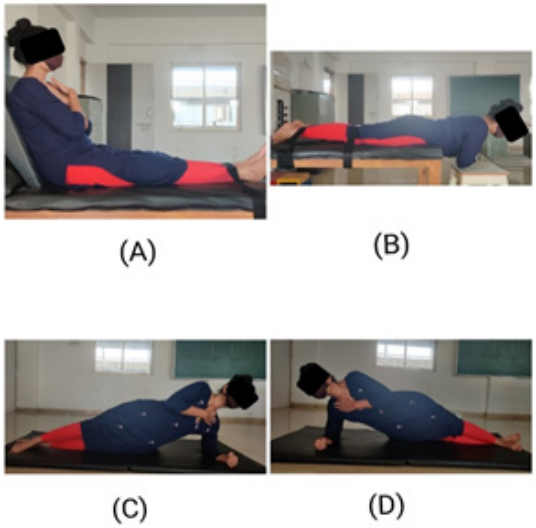


[Fig-3]: showing exercises for the control group.

For the first two weeks, training repetitions per set for curl-up, side-bridge, and bird-dog were 5, 4, and 3, respectively. Training repetitions per set were 7, 6, and 5 for the third and fourth weeks. And in the last two weeks, training repetitions per set were 9, 8, and 7, respectively. For each exercise, the participants held the position for 8-10 seconds and were given 30 seconds of rest between the sets [2].

Outcome measure:

1. McGill endurance test [10] consisted of three subtests: [Fig-3]



[Fig-4]: McGill endurance test *(A) Flexor endurance test (B) Extensor endurance test (C) Left side bridge test (D) Right side bridge test

1) Flexor endurance test: An angle of 60 degrees was made from the test bed, and participants were instructed to sit with their bodies against support on the test bench. Both hip and knee joints were flexed to 90 degrees. Arms were folded across the chest with hands on the opposite shoulder and toes under the toe straps. To begin the test, the supporting wedge was pulled 10 cm back. During that period, participants were instructed to maintain that position. If the upper body fell below 60 degrees, the test was over.

2) The side-bridge test: This test required participants to lay on their sides with legs extended on a 2.5 cm thick exercise mat. The top foot was placed in front of the bottom foot for support. Participants could get support from one elbow and their feet. Participants were asked to lift their hips off the mat and maintain a straight line over their full-body length. The unsupported arm could be placed on the opposite shoulder across the chest. When the hips returned to the exercise mat, the test was over.

3) The extensor endurance test: This test required a test bench approximately 25 cm above the floor. Participants were prone with ankles, knees, and hips fixed to the test bed and upper body extended over the edge of the test bench. Participants were asked to rest their upper bodies on the floor before exerting. At the beginning of the test, upper limbs were held across the chest, and the upper body was lifted off the floor until it was horizontal to the floor. Participants were instructed to maintain the horizontal position for as long as possible. The time until the participants came in contact with the floor again was recorded.

2. Exergame Enjoyment Questionnaire (EEQ):

A 20-item questionnaire was created as a novel instrument to measure the enjoyment level of participants during the exergame session. For calculating the total score, points based on responses were added for each question. For questions 1, 2, 3, 5, 7, 8, 12, 14, 15, 16, 17 and 20 responses were scored as 1, 2, 3, 4, 5 points (strongly disagree, disagree, neutral, agree, strongly agree). For questions 4, 6, 9, 10, 11, 13, 18, and 19, responses were scored as 5, 4, 3, 2, and 1 point (strongly disagree, disagree, neutral, agree, strongly agree). The minimum possible score was 20 points, and the maximum was 100. A higher score indicated more enjoyment. Questions were administered to participants immediately after playing an exergame [11].

STATISTICAL ANALYSIS

The collected data was organized and analyzed using SPSS software (version 26). The p-value of <0.05 was considered statistically significant. The Shapiro-Wilk test checked normality distribution for all data, and the p-value was >0.05. So, the paired t-test was performed to compare pre and post-effect in both the groups and the Unpaired t-test was done to compare the intervention and control groups.

RESULTS

The mean age, height, weight, and male/female ratio of participants have been stated in [Table 1].

	Intervention group (n=15)	Control group (n=15)
Sex (male/female)	8/7	7/8
Age (years)	(23.73 ± 3.34)*	(24 ± 3.77)*
Height (cm)	(156.8 ± 4.49)*	(156.2 ± 3.41)*
Weight (kg)	(59.53 ± 7.45)*	(59.46 ± 5.90)*

[Table 1] General characteristics of the participants. *Values are presented as mean ± standard deviation.

Within-group analysis from [Table 2] showed a significant difference in all the four subtests of the McGill endurance test after the endurance training in both the intervention and control groups. However, the intervention group showed significant differences with a p-value < 0.01 (sig. 2-tailed). Between-group analysis showed that the endurance time significantly improved in the intervention group compared to the control group with a p-value <0.01 [Table 3].

	Pre	Post	t value	P value
INTERVENTION GROUP				
Flexor endurance test	(27.14 ± 6.72)*	(46.22 ± 8.50)*	19.18	<0.01
Extensor endurance test	(14.90 ± 3.21)*	(30.55 ± 4.55)*	15.72	<0.01
Right side bridge test	(14.37 ± 4.14)*	(20.36 ± 3.83)*	10.88	<0.01
Left side bridge test	(13.27 ± 3.66)*	(17.30 ± 3.49)*	16.06	<0.01
CONTROL GROUP				
Flexor endurance test	(25.64 ± 4.68)*	(34.19 ± 4.54)*	14.70	<0.05
Extensor endurance test	(14.17 ± 3.24)*	(22.03 ± 3.40)*	17.94	<0.05
Right side bridge test	(13.30 ± 2.46)*	(16.90 ± 2.87)*	12.24	<0.05
Left side bridge test	(12.73 ± 2.36)*	(15.56 ± 2.44)*	22.13	<0.05

[Table 2] Pre and post value of endurance time (seconds) of all four sub test in intervention and control group. *Values are presented as mean ± standard deviation.

	Intervention group	Control group	P value
Flexor endurance difference	(19.07 ± 3.85)*	(8.54 ± 2.25)*	<0.01
Extensor endurance difference	(15.64 ± 3.85)*	(7.86 ± 1.70)*	<0.01
Right side bridge difference	(5.99 ± 2.13)*	(3.59 ± 1.14)*	<0.01
Left side bridge difference	(4.03 ± 0.97)*	(2.83 ± 0.49)*	<0.01

[Table 3] Comparison of difference in endurance time (seconds) before and after the treatment between intervention and control group. *Values are presented as mean ± standard deviation.

The EEQ responses' mean and standard deviation of the scores was 80.73 ± 7.81. Again, multiple scores in the higher range were noted, which indicated more enjoyment in this exergame.

DISCUSSION

The present study was aimed at determining the effect of exergaming on trunk muscle endurance and enjoyment in young adults. The exergaming group had shown a significant difference in improving trunk muscle endurance compared to the control group. The core stability exercises chosen in both groups improve motor control and coordination of trunk muscles, stimulate proprioception, and improve physiological function and balance sense. These exercises will be helpful in the prevention and rehabilitation of low back pain and improve balance in different age groups [12].

The present result in the exergaming group may be due to the games chosen to play that mainly focus on trunk movements and core muscle activation. Another factor responsible for improvement may be the competition of final scores between the participants and natural environment stimulation by the exergames [8]. Also, introducing these exergames can provide immediate feedback regarding visual or auditory results or scores of the exercise, increasing the exercise learning effect [13].

Similar other studies have recorded results of the exergaming effect. Vojciechowski AS et al. (2017) observed exergame training's effects on the health promotion of young adults and reported that exergame training improved skeletal muscle function and exercise adherence in active young adults [8]. Park J et al. (2014) conducted a study with Nintendo Wii fit to find its effects on normal adults' trunk muscle activities and lower extremities. They also provided Nintendo Wii fit training thrice a week for six weeks. They reported an effective intervention for improving trunk muscle and lower limb activities in normal adults [14]. Park EC et al. (2015) conducted a study with a virtual reality game and conducted exercise sessions for 30 minutes thrice a week for eight weeks in the elderly and found that virtual reality training could improve balance and gait [13]. Lee D et al. (2014) did a study to find the effect of indoor horseback riding and virtual reality (Nintendo Wii fit three times a week for six weeks) on the dynamic balance of healthy adults and concluded that dynamic balance ability improved and virtual reality could be used as an additional exercise for postural control [15].

In this study, a new exergame Nintendo Ring Fit Adventure, showed good enjoyment levels across the participants. Enjoyment during exercise is an important factor for psychological well-being and regular participation and for the realization that health can be achieved with enjoyable activities. To improve motivation, adherence, and enjoyment, new games can be added for different age groups in the future. Mellecker R et al. (2013) concluded from a narrative review that the aerobic exercise component and fun generated by the game provided a physiological and psychological benefit to the participants and encouraged them to perform better to improve their score or beat other participants in the game [16]. Based on a systematic review, Lee S et al. (2017) reported that different psychological effects like enjoyment, immersion, flow, energy expenditure and feedback modality were seen during exergame play [17]. Limperos AM et al. (2016) reported that exergame performance was related to full

enjoyment and the possibility of future game use for treatment purposes [18].

From this study and available literature, the advantages of Nintendo® Ring Fit Adventure exergame are: First, in the current COVID-19 pandemic, it is easy to do fitness at home without the supervision of a physiotherapist, and second, it is inexpensive and provides motivation and enjoyment. This seems to be a great new technology that society may adapt for future health and exercise.[9]

LIMITATION AND FUTURE RESEARCH:

Limitations of the present study are as follows: Firstly, this study included a very small sample of participants and was only from Ahmedabad (Gujarat, India), so the generalization of this result is difficult. Secondly, follow-up for effect was not taken so that future studies can be done with a larger sample size from different places with long-term follow-ups.

CONCLUSION

An exergame can be used to improve physical fitness in adjunct with traditional exercises. This new exergame Nintendo® Ring Fit Adventure, which is newly launched and specifically focused on physical fitness can be a great advantage to use as a rehabilitation tool in different conditions. A video game-based rehabilitation can also be a new treatment mode in India in this technological world.

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