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Nintendo Ring Fit Adventure improves balance ability in sedentary young adults

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Abstract

Introduction. Exercising with a game console is a novel type of exercise. One game that is currently popular is Nintendo Ring Fit Adventure, but its impact on balancing ability in young adults who are sedentary has yet to be investigated. This study aimed to investigate the effects of Nintendo Ring Fit Adventure exercise on balance ability in young adults with sedentary lifestyles.
Methods. Thirty participants were randomly divided into two groups: the Nintendo and control groups. The experimental group completed a workout routine using the Nintendo Ring Fit for 30 minutes per day, three times per week for four weeks, while the control group received no intervention. Participants' balance abilities were evaluated pre- and post-intervention by the single leg stance test, Modified Clinical Test of Sensory Interaction in Balance (MCTSIB), and limit of stability. A one-way ANCOVA with the pre-intervention value as a covariate was used to compare groups.
Results. Comparisons between groups after the intervention revealed a significant decrease in MCTSIB sway for the firm surface with eyes open condition ($p = 0.043$) and a significant increase in endpoint excursion in the backward direction ($p = 0.038$). The other variables did not show statistically significant differences between groups.
Conclusions. Exercise with Nintendo Ring Fit improved the participants' ability to balance in certain dimensions. Nintendo Ring Fit may increase the balance ability of young adults with sedentary behaviour.
Key words: exergame, postural balance, sedentary behaviour, young adult

Introduction

Most healthy people, particularly young individuals, consider balance non-essential to their health or daily routine. However, accidents and injuries related to balance are rather common. According to the Web-based Injury Statistics Query and Reporting System, Centers for Disease Control and Prevention, USA (2015), young individuals and the elderly have a comparable risk of falling [1]. Falling accounts for 28% of all brain injuries [2]. Seventy percent of head injury victims are children, teens, or young adults [2]. Young individuals reportedly have a greater risk of falling when jogging, exercising, or participating in other activities. Hand, wrist, ankle, and knee injuries are common in this demographic [3].

The ability to balance is typically defined as the capacity to keep the body's centre of gravity (COG) or vertical line from the centre of mass inside the support base with minimal body sway. Balance control goals include preserving postural stabilisation during exercises, monitoring leg motion during walking, and minimising head-related acceleration to maintain vision and head position [4]. Three primary sensory systems are involved in the control of balance: the vision, vestibular, and somatosensory systems. These three mechanisms work together to maintain the ability to balance effectively. The vision system is the sensory system mainly used by young adults to achieve optimum equilibrium [5]. In conjunction with a deficiency of visual feedback, voluntary muscular contraction can deteriorate standing posture [6]. The findings of a study comparing the balance ability of young adults with physically active or sedentary lifestyles showed that a sedentary lifestyle was linked to deficits in the ability to balance [7]. In other words, the ability to balance was compromised for young adults with sedentary behaviour. Therefore, before their balance ability becomes compromised and causes complications such as falls, slips, and fractures, young people should pay more attention to balance.

Exergames are games that enhance body mobility, flexibility, balance, and strength, and have recently grown in popularity. Several prior studies have demonstrated that exergames can help with balance improvement. For example, Siriphorn and Chamonchant [8] demonstrated that using a Wii balance board enhanced balance by improving the parameters of limit of stability (LOS) testing and increasing the strength of the hip flexors, knee flexors, dorsiflexors, and plantar flexors. Gioftsidou et al. [9] conducted a comparison of traditional and exergame exercise. They discovered that both groups exhibited comparable balance improvement. Exercising with an exergame is more pleasurable and engaging than standard balancing exercises. Thus, exergames may be used instead of traditional exercise to enhance balance [9]. Furthermore, Subramanian et al. [10] conducted a study that examined the elements that encourage exergame training in young people and older adults. They discovered that internal factors, such as game difficulty, and external factors, such as in-game prizes, inspired young adults. Older individuals were driven by internal factors, such as enjoyment of the games, but they were also driven by external factors, such as the health benefits of gaming [10]. Based on these findings, it appears that using exergames to enhance balance in young people with sedentary lifestyles

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might be beneficial. A new form of exergame, recently launched in October 2019, is Nintendo Switch: Ring Fit Adventure. This exergame equipment consists of a portable ring gadget used as a joy controller and a leg strap used to control the movement of a video game character. These games include fantastical avatars that can be controlled by real-life body movements such as jogging, sprinting, and high knees. Exercising with Ring Fit Adventure may improve the player's balance. However, no research has been conducted to demonstrate the health effects of Ring Fit Adventure. The purpose of this study was to investigate how a Nintendo Ring Fit exergame benefited balance in young adults with sedentary lifestyles. The research question was, 'Did playing Nintendo Ring Fit Adventure three times per week for four weeks improve the balance abilities, i.e., single-leg stance, sensory interaction in balance, and limit of stability, of young adults with sedentary behaviour?' We hypothesised that playing Nintendo Ring Fit Adventure would improve balance abilities in young people compared with individuals in a control group who did not exercise.

Subjects and methods

Participants

Thirty young adults were recruited for this study. The following were the inclusion criteria: (1) young individuals between the ages of 18 and 35 years, (2) exercising for less than 30 minutes per day with no participation in an exercise program in the three months before participation in this research, (3) ability to read and write Thai, (4) no vision difficulties that cannot be remedied with corrective lenses, (5) no hearing difficulties, (6) ability to stand on both legs with the eyes closed for 30 seconds, (7) ability to stand on one leg alone for 30 seconds, and (8) no musculoskeletal system disorders that affect the ability to balance in the six months before the study. Exclusion criteria were as follows: (1) the participant is injured or falls during the trial, (2) the participant decides to withdraw from the study, and (3) the participant exercises less than 80% of the time required by the protocol (less than 10 of 12 exercise sessions).

Sample size calculation

The sample size was calculated using G*power software version 3.1.9.7 (University of Düsseldorf, http://www.psycho.uni-duesseldorf.de/departments/aap/gpower3/) with an effect size of 0.5, alpha of 0.05, power of 0.80, and drop rate of 15%. Results indicated that at least 30 participants were required.

Blinding and concealment

Participants were randomly divided into two groups of 15 people. The group assignment was masked by the use of computer-generated random numbers in opaque, sealed envelopes, which were unsealed in the participant's presence following completion of the baseline assessment. Participants could not be blinded due to the transparent nature of the intervention. A researcher who was unaware of the group assignment assessed the outcomes.

Interventions

The experimental group played Nintendo Switch: Ring Fit Adventure for 30 minutes per day, three days per week for four weeks. Participants in the control group maintained their normal lifestyle and were asked to refrain from physical exercise while taking part in the study. During the trial, all participants were required to log the days they exercised and record any adverse effects that occurred during exercise before their subsequent exercise session. A research assistant was instructed to provide monitoring to safeguard the participants if they lost their balance. The Ring Fit Adventure game was played on a Nintendo Switch™ console connected to a TV through a Nintendo Switch dock. The Joy-Con™ controllers were attached to the Ring Con™ and leg strap component to detect arm and leg movements, respectively. The game was played in adventure mode by controlling the joystick through the Ring-Con™ and the leg strap, such as moving the Ring-Con™ to step up, squeezing the Ring-Con™ to generate air bombs, and using a knee lift to climb up stairs or jump.

Outcome measurements

A Balance Master System (Natus Medical Inc., Pleasanton, CA, USA) was used for all outcome measures, which consisted of a dual force plate coupled to the machine. All tests were carried out with a two-minute rest period between each test. The test was terminated when the individual could not stand still for more than 10 seconds, opened their eyes in conditions that required keeping the eyes closed, or moved their hands off their hips or stretched out their arms to maintain equilibrium or gain support for balance. These outcomes were tested twice before the intervention (week 0) and within 1–2 days following the exercise program (week 4) (Figure 1). The following three tests were carried out:

1. Single leg stance test: This test assessed the participant's static balance while standing on one leg by asking them to lift one leg off the ground. The customary command was 'Stand on one leg for as long as possible by standing tall, set your hands on your hips, and look straight ahead'. The test consisted of two conditions: open and closed eyes. The sway velocity of the centre of gravity (COG sway velocity) was measured in degrees per second.

2. LOS test: This dynamic balancing test estimated the greatest distance that the participant could lean in four directions. The participant was instructed to stand upright on the force plate and lean in four directions, each 90 degrees away from the other, to transfer a cursor to a target. The participant was instructed to 'stand tall, lean towards the target as far as possible and as quickly as is feasible without moving the legs or bending the torso'. When assessed in all direc-

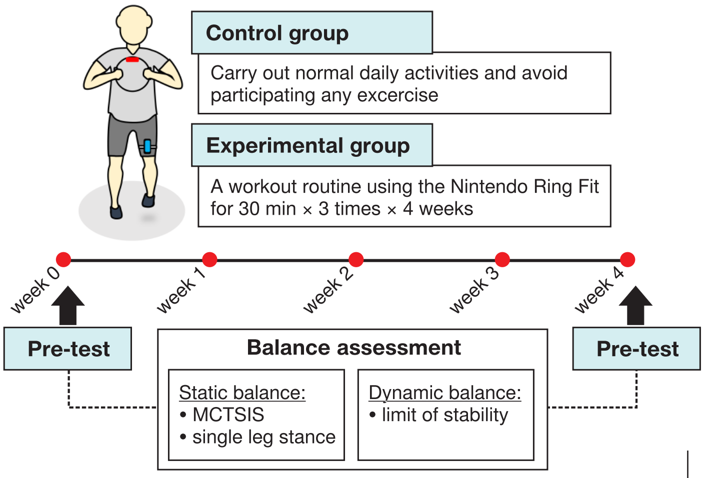

Figure 1. Schematic view of the protocol

tions, the NeuroCom Balance Master gave the following parameters: (1) maximum distance (maximum excursion), (2) response time from the start of the test, (3) average velocity of movement (COG velocity of movement), and (4) distance to the end of the first movement in the direction of the target (endpoint excursion).

3. Modified Clinical Test of Sensory Interaction in Balance (MCTSIB): The purpose of this test was to observe the fluctuation of COG as the individual stood stationary with their hands on their hips. The test was carried out in four different ways: (1) standing on the floor with the eyes open (Firm + EO), (2) standing on the floor with the eyes closed (Firm + EC), (3) standing on a foam surface with the eyes open (Foam + EO, and (4) standing on a foam surface with the eyes closed (Foam + EC). Each test was performed for 10 seconds. After completing all measurements, the NeuroCom Balance Master provided the COG sway velocity in degrees per second.

Statistical analysis

Statistical analysis was performed in the MedCalc® statistical software version 20.008 (MedCalc Software Ltd., Ostend, Belgium). The D'Agostino–Pearson normality test was used to examine the data distribution. A logarithmic conversion was applied for the parameters that were discovered to have a non-normal distribution. However, the statistics were reported in their original units. The parametric variables were analysed using one-way ANCOVA with baseline data as covariates. Levene's test for equality of error variances was performed, and the assumptions were fulfilled. For pairwise comparisons, the Bonferroni test was used as a post hoc test. A significance threshold of $p < 0.05$ was set.

Ethical approval

The research related to human use has complied with all the relevant national regulations and institutional policies, has followed the tenets of the Declaration of Helsinki, and has been approved by the Institutional Research Ethics Review Committee for Research Involving Human Research Participants (COA No. 190/2020). This randomised control trial was registered in the clinical trial registry under ID: TCTR2020 1218002 at www.thaiclinicaltrials.org.

Informed consent

Informed consent has been obtained from all individuals included in this study.

Results

Figure 2 depicts the flow of participants in a consort chart. Table 1 shows the characteristics of the participants. Except for the maximum excursion of LOS in the right and left directions, there were no statistically significant differences in any of the baseline characteristics and most baseline tests. There was a significant difference between the MCTSIB group in the Firm+EO condition ($F(1,27) = 4.51$, $p = 0.043$, effect size $d = 0.80$) and endpoint excursion in the backward direction ($F(1,27) = 4.76$, $p = 0.038$, effect size $d = 0.83$). Post hoc tests revealed a significant difference between groups for the MCTSIB in the Firm + EO condition ($p = 0.04$) and endpoint excursion in the backward direction ($p = 0.04$) (Table 2 and 3). The estimated marginal means showed that compared with the control group, the Ring Fit group showed less sway during the MCTSIB in the Firm + EO condition (mean = 0.20°/s vs. 0.27°/s) and a higher endpoint excursion of the LOS test in the backward direction (mean = 71.02% vs. 58.58%) (Table 2 and 3).

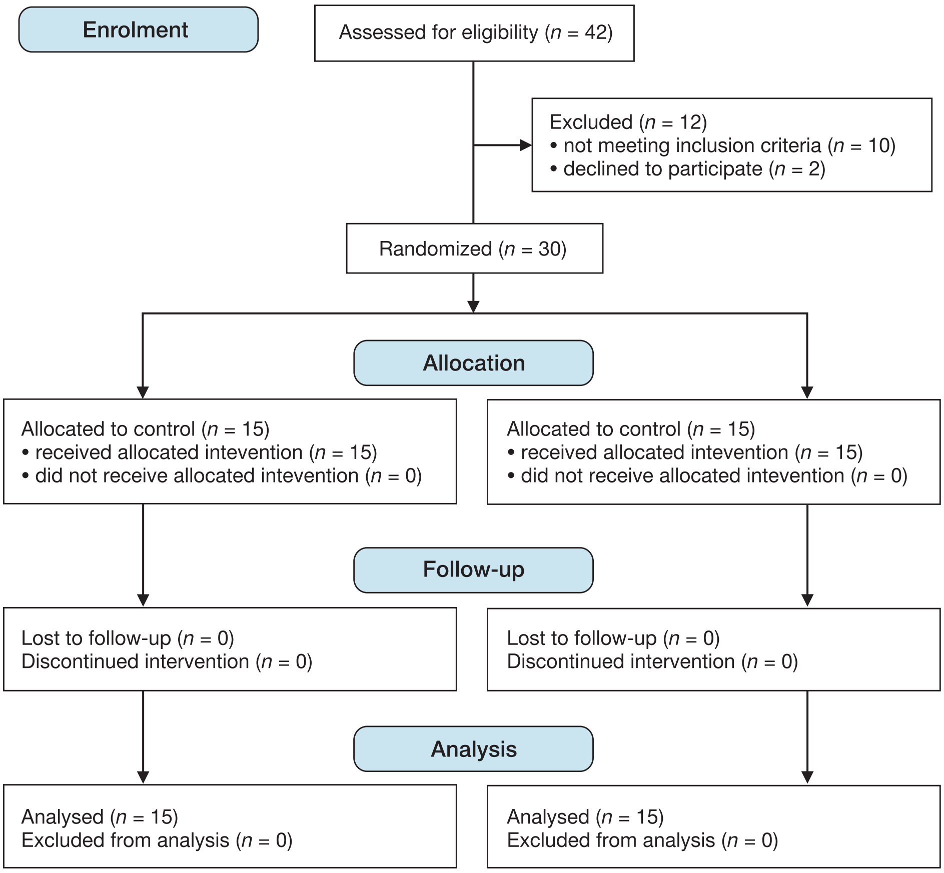

Figure 2. Consort flow diagram

Table 1. Characteristics of the participants and baseline results

Variable		Control (*n* = 15)		Ring Fit (*n* = 15)		*p*
		mean	*SD*	mean	*SD*	
Age (years)		21.53	1.25	21.47	1.46	0.89
Weight (kg)		60.31	16.50	61.79	12.80	0.79
Height (m)		1.64	0.08	1.61	0.06	0.33
BMI (kg/m^2)		22.12	4.04	23.73	4.77	0.33
MCTSIB (°/s)	Firm + EO	0.25	0.15	0.22	0.12	0.64
	Firm + EC	0.24	0.07	0.18	0.11	0.06
	Foam + EO	0.38	0.12	0.32	0.13	0.21
	Foam + EC	0.56	0.15	0.49	0.22	0.34
SL (°/s)	EO	0.83	0.24	0.85	0.21	0.78
	EC	1.90	0.38	2.11	0.53	0.23
LOS Reaction time (s)	F	0.79	1.25	0.27	0.12	0.12
	R	0.51	0.29	0.41	0.21	0.29
	B	0.97	0.38	0.86	0.19	0.31
	L	0.95	0.36	0.91	0.26	0.77
LOS Movement velocity (°/s)	F	4.53	2.87	6.15	2.11	0.09
	R	7.34	3.27	8.51	3.86	0.38
	B	3.34	1.51	3.54	1.69	0.73
	L	8.66	4.37	7.95	3.81	0.64
LOS Endpoint excursion (%)	F	78.00	28.10	74.80	19.15	0.72
	R	82.07	24.57	75.13	21.92	0.42
	B	64.13	17.94	72.87	21.54	0.24
	L	99.13	14.09	95.60	11.35	0.46
LOS Maximum excursion (%)	F	103.60	10.36	96.73	13.50	0.13
	R	105.00	5.52	100.07	6.03	0.03*
	B	83.13	14.04	89.00	14.69	0.27
	L	107.67	8.19	100.47	6.94	0.01*

MCTSIB – Modified Clinical Test of Sensory Interaction in Balance, SL – single leg stance test, LOS – limit of stability
Firm – firm surface, Foam – foam surface, EO – eyes open, EC – eyes closed, F – forward, R – right, B – backward, L – left
* significant difference

Table 2. ANCOVA results for static balance outcomes, i.e., MCTSIB and SL

Test	Condition	Control (*n* = 15)		Ring Fit (*n* = 15)		Pairwise comparisons		
		mean	*SE*	mean	*SE*	diff.	*p*	95%CI
MCTSIB (°/s)	Firm + EO	0.27	0.02	0.20	0.02	0.07	0.04*	0.002 to 0.14
	Firm + EC	0.24	0.04	0.20	0.04	0.04	0.49	–0.09 to 0.18
	Foam + EO	0.37	0.04	0.33	0.04	0.04	0.49	–0.07 to 0.15
	Foam + EC	0.56	0.05	0.51	0.05	0.06	0.40	–0.08 to 0.19
SL (°/s)	EO	0.80	0.04	0.74	0.04	0.07	0.24	–0.05 to 0.18
	EC	1.87	0.13	1.88	0.13	–0.01	0.97	–0.40 to 0.38

MCTSIB – Modified Clinical Test of Sensory Interaction in Balance, SL – single leg stance test
Firm – firm surface, Foam – foam surface, EO – eyes open, EC – eyes closed
* significant difference

Table 3. ANCOVA results for dynamic balance outcomes, i.e., LOS

LOS parameters		Control (*n* = 15)		Ring Fit (*n* = 15)		Pairwise comparisons		
		mean	*SE*	mean	*SE*	diff.	*p*	95%CI
Reaction time (s)	F	0.75	0.07	0.58	0.07	0.16	0.12	–0.04 to 0.37
	R	0.49	0.05	0.60	0.05	–0.11	0.13	–0.25 to 0.035
	B	0.63	0.08	0.84	0.08	–0.21	0.06	–0.43 to 0.01
	L	0.54	0.04	0.57	0.04	–0.03	0.60	–0.14 to 0.08
Movement velocity (°/s)	F	7.52	0.76	6.12	0.76	1.39	0.22	–0.88 to 3.67
	R	8.58	0.73	9.58	0.73	–1.00	0.35	–3.13 to 1.13
	B	4.32	0.40	4.07	0.40	0.25	0.67	–0.92 to 1.42
	L	8.83	0.77	9.35	0.77	–0.52	0.64	–2.77 to 1.73
Endpoint excursion (%)	F	86.80	4.56	79.20	4.56	7.60	0.25	–5.65 to 20.84
	R	87.02	3.41	84.51	3.41	2.51	0.61	–7.44 to 12.45
	B	58.58	3.98	71.02	3.98	–12.44	0.04*	–24.14 to –0.74
	L	92.69	2.59	95.45	2.59	–2.76	0.46	–10.32 to 4.80
Maximum excursion (%)	F	102.32	2.06	97.88	2.06	4.43	0.15	–1.68 to 10.55
	R	102.26	1.05	101.21	1.05	1.05	0.50	–2.12 to 4.22
	B	74.92	3.79	83.61	3.79	–8.69	0.12	–19.81 to 2.43
	L	100.00	1.74	104.07	1.74	–4.07	0.13	–9.38 to 1.23

LOS – limit of stability, F – forward, R – right, B – backward, L – left
* significant difference

Discussion

According to this study, Ring Fit training lowered the COG sway velocity of the MCTSIB while standing on the floor with the eyes open and enhanced backward endpoint excursion in young individuals with sedentary lifestyles. However, other parameters did not differ significantly between the Ring Fit training and control conditions. These results suggested that the balancing ability of sedentary young adults improved in various dimensions after exercising with Nintendo Ring Fit Adventure.

Sedentary behaviour is a risk factor for chronic illnesses [11]. Sedentary lifestyles can be minimised by increasing physical activity, resulting in better health. There are various techniques to encourage physical activity. Exergames are an alternative method of promoting body movement, and they may be used to develop a challenging and fun balancing training program that promotes weight shift, muscular activation, and internal drive [12]. Exergames assisted in reducing sedentary behaviour and improving health status and recovery in a variety of circumstances [13]. Nintendo Switch: Ring Fit Adventure allows participants to interact with the games while performing activities and yoga exercises. This study suggests that exercise with Nintendo Switch: Ring Fit Adventure may improve participants' ability to receive visual information for maintaining balance, as Ring Fit training provided visual feedback from the monitor to challenge participants to move their bodies in response to the assigned activity or body movement. As a result, exergame training can improve eye–body synchronisation [14]. Training with visual feedback helps improve balance ability by stimulating motor planning and control capacity [15]. Furthermore, the game's feedback on participants' performance and actions can boost motor skill acquisition [16]. As a result of Ring Fit training, participants may use visual information more effectively to adjust postural stability, resulting in less body sway.

Significant connections were established between postural variables and postural stability, i.e., the higher the postural sway, the more pronounced the body posture abnormalities [17]. Because of the link between posture factors, rehabilitation exercises are necessary for improved postural stability. Furthermore, compared with the control condition, Ring Fit training encouraged participants to stretch their trunks backwards. Participants were required to move their bodies in response to the game; therefore, the training required them to use visual information to change their body position to perform specific movements in response to the command on the display [18]. Our study observed an increase in backward endpoint excursion as a result of improved anticipatory adjustment (feedforward control) of the magnitude of the movement following Ring Fit training. A probable explanation for these results is that the Nintendo Ring Fit monitors the subject's movement and provides feedback on the screen, facilitating the subject's motor learning. Practice may have taught the individuals how to change their body weights and coordinate their bodies in order to perform fluid movement and reach various target positions. Furthermore, Shih et al. [19] discovered that exergame training improved postural stability in participants with Parkinson's disease by improving LOS, particularly in the backward direction, more than traditional training, thus, the exergame enhanced endpoint excursion [19]. Eggenberger et al. [20] investigated the impact of exergame training on prefrontal cortex activity and executive function in older adults. The training decreased prefrontal cortex activity, which was linked to improved executive function, promoting concentrated attention while walking following exercise training. The exergame in the study was dancing, which incorporated cognitive and motor training simultaneously [20].

However, no changes in other parameters were observed in this study. One possible explanation is that Nintendo Ring Fit Adventure is a dynamic balance training activity, but the MCTSIB and single leg stance exams are static balance assessments. A previous study conducted with 77 physically active college students used a force platform and the Y balance test, respectively, to evaluate both static and dynamic aspects of balance. It was discovered that there is only a weak association between static balance and dynamic balance in terms of controlling posture [21], which can perhaps corroborate the results of this study. Because the individuals trained on a stable surface with their eyes open, the improvements were only noticed in the condition with their eyes open and on a firm surface. In addition, it appears that the training intervention was not explicitly designed to improve balance, and as a result, no further benefits were discovered during the study.

Limitations

This study had some limitations. The study's primary drawback is that the Nintendo training was not explicitly designed to enhance balance, and the findings were not compared to those obtained from a typical balance training intervention. By including a control intervention based on traditional balance training, the effect of balance training on sedentary persons would have been clarified. In addition, it is conceivable that selecting in-game routines that target the core stabilisers and lower limb muscles may enhance outcomes when exercising with Nintendo Ring Fit Adventure. Future studies should also include muscular strength and aerobic capacity tests that are more similar to those used in the game to demonstrate the specificity of training.

Conclusions

Nintendo Ring Fit Adventure may be utilised as a form of exercise to enhance balance in young people who are sedentary. It can improve balance in various dimensions, including MCTSIB in the Firm + EO condition and endpoint excursion in the backward direction, demonstrating the training's beneficial effects on anticipatory postural adjustments and integrating visual information for postural control.

Availability of data and material

The datasets generated during and analysed during the current study are available in the figshare repository, https://doi.org/10.6084/m9.figshare.15043026.v3.

Disclosure statement

No author has any financial interest or received any financial benefit from this research.

Conflict of interest

The authors state no conflict of interest.

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