# The effect of rebound exercise on cognition and balance of females with overweight and obesity

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# The effect of rebound exercise on cognition and balance of females with overweight and obesity

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**ABSTRACT**

Balance issues have been reported to be common among females with overweight or obesity with associated fall risks. Despite the increasing reports of the negative impacts of obesity on balance and cognition, there is a scarcity of research aimed at evaluating effective interventions. To examine the effects of rebound exercises on cognition and balance among females with overweight and obesity. This Quasi-experimental study used the purposive sampling method to recruit 20 female students (aged 17–35 years) with overweight and obese at the Evangel University Akaeze, Ebonyi State Nigeria. Rebound exercise intervention was administered to all participants at the gym for 30 minutes in each session, three times a week for six weeks, while their cognitive performances, stationary balance, and dynamic balance were measured pre-and post-trial using Trail Marking Test Apparatuses, Unilateral Pedal Tests, and Meter Backward Walk Test respectively. There was a significant ($p < 0.001$) difference in the participants' cognition values across weeks 1, 3, and 6 with a progressive improvement over time. There was also a significant ($p < 0.05$) difference in the participants' static and dynamic balance values across weeks 1, 3, and 6 with a progressive improvement in balance performance over time. Rebound exercise significantly improved the cognition and balance of females with overweight or obese. This finding suggests a promising intervention to improve balance and cognitive-related problems in this population. Registered retrospectively in the Pan African Clinical Trial Registry, identification number for the registry is PACTR202405746557031. Dated 2 May 2024.

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**KEYWORDS**
Rebound exercise; cognition; balance; obesity; females with overweight; Nigeria

## 1. Background

Obesity and overweight are major global health concerns that are associated with various physical and mental health complications [1]. This condition has become an alarming global epidemic, with its prevalence increasing threefold over the last 48 years and causing approximately 2.8 million deaths per year [2]. At least one-third of the world's population is either overweight or obese [3], with women being more affected than men, as recent studies have reported a 2.72 times higher likelihood of obesity in women compared to men [4]. Obesity is associated with chronic low-grade inflammation and metabolic dysfunction, which can lead to changes in the brain, including alterations in neural structure and function, potentially affecting cognitive processes [5].

There is growing evidence that obesity can indeed have implications for cognitive functioning, and this concern extends to both males and females. Studies have shown that increased body mass index is linked to decreased cognitive performance, likely due to increased levels of the inflammatory C-reactive protein (CRP), which is responsible for neuroinflammation [6,7]. Neuroinflammation can affect balance by affecting various parts of the brain and nervous system involved in motor control and coordination, including disrupting neural pathways that are crucial for maintaining balance [8], impairing motor neurons, leading to muscle weakness and impaired coordination [9], impact on the vestibular system leading to dizziness, vertigo, and balance disorders [9], as well as can impair cognitive functions and sensory integration, making it harder for the brain to process and respond to balance-related information from the body [10]. Some studies suggest that obesity may be a stronger risk factor for cognitive decline and Alzheimer's disease in women than in men [11]. Women are also more likely to have certain obesity-related conditions, such as polycystic ovary syndrome (PCOS) and hormonal fluctuations, which could interact with cognitive function [12]. Cognitive functioning

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is a crucial aspect of overall health, encompassing mental processes such as attention, memory, executive function, and decision-making. Apart from cognitive dysfunction, balance problems have also been linked to obesity. Studies have identified body weight as a strong predictor of balance, suggesting that individuals with overweight or obesity are prone to balance deficits and falls [13,14]. These balance problems arise from several factors, including decreased muscle strength, impaired proprioception, altered biomechanical changes, joint degeneration, and psychological factors [13–15]. Cognitive decline and impaired balance are often overlooked yet critical aspects of health in this population, contributing to a cycle of reduced physical activity, increased sedentary behaviour, and further weight gain.

Aerobic exercise has been proven to effectively manage obesity, promote weight loss, improve cardiovascular health, and enhance overall well-being [16–18]. Among the different forms of aerobic exercise, rebound exercise stands out as a low-impact and enjoyable option. It involves repetitive bouncing on a trampoline. Rebounding utilizes gravity and forces of acceleration and deceleration to increase oxygen consumption and stimulate the immune system in a unique way that other exercises may not do [19]. The up-and-down movement in rebounding facilitates lymphatic flow, which transports immune cells throughout the body. This exercise can strengthen leg muscles, improve endurance, and promote stronger bones, among other benefits [20]. It is particularly ideal for individuals with overweight or obesity because it is low-impact and the body weight is mostly absorbed by the trampoline surface while the rest is evenly distributed throughout the body, minimizing the risk of stress injuries [21]. Studies have shown that rebound exercise is effective in improving balance [16,22] and in the training of cognitive functions [23–25] in the wider population.

While previous studies have explored the benefits of rebound exercise on weight management [26–28], neurological rehabilitation [29,30], and cardiovascular health [31], there is still a notable gap in research regarding its potential impact on cognitive function and balance, especially among individuals with overweight or obesity. Since rebound exercises have been linked to balance improvement in the wider population [26–31], this study hypothesizes that it could be an effective intervention for people in this population. The study thus aims to investigate the effects of rebound exercise on cognition and balance in females with overweight and obese. the findings can help inform sex-specific interventions and healthcare strategies that are relevant for female participants who face unique challenges in managing their health and weight-related issues.

## 2. Methods

### 2.1. Participants

This Quasi-experimental study used the purposive sampling method to recruit 20 female students (aged 17–35 years) with overweight and obese at the Evangel University Akaeze, Ebonyi State Nigeria. A preliminary power analysis showed that a sample size of 20 was needed for the analysis of variance (ANOVA) for cognitive changes at degree of freedom (df) = 1, to achieve 96% (0.96) power with a moderate to large effect size of 0.60 at an alpha level of 0.05 [32]. The inclusion criteria were for females with overweight and obesity who were within the age range of 17–35 years and willing to participate. Participants were screened for the exclusion criteria using a short checklist questionnaire item that asked the participants if they had current cardiopulmonary and cardiorespiratory dysfunction as these conditions are contraindicated in moderate to high-intensity aerobic exercise, having current atlantoaxial instability as rebounding aggravates neck pain in such condition, phobia for bouncing, lower limb arthritis, and pregnant females as any ballistic exercise is contraindicated in pregnancy. The study's design, potential hazards, and associated discomfort were communicated to the participants, who then provided written informed consent prior to enrolment. The study was approved by the Health Research and Ethics Committee of the University of Nigeria Teaching Hospital, Ituku-Ozalla, Enugu State. All authors signed an informed consent form, and it was conducted according to the recommendations in the Declaration of Helsinki.

### 2.2. Study apparatus

The exercise intervention was carried out with a 48-inch Rebounder trampoline (model: HomeFitnessCode, UK) which the participants had to jump on repeatedly. The heights and weights of the participants were measured using a stadiometer (model: Seca 213, Germany), and their BMI was calculated as weight in kilograms divided by height in meters squared. A stopwatch (model: Seiko W073, UK) was used to record trial time during the various tests in the study. A tape rule (model: Omron X4, UK) was used to determine the distance participants used during the dynamic balance test.

The outcome measure for participants' cognitive performance in this study was the Trail Making Test Apparatuses (TMT). The TMT is a neuropsychological test of visual attention and task switching. The test can provide information about visual search speed, scanning, speed of processing, mental flexibility, and executive functioning [33]. It has parts A and B, in which the subject was instructed to connect a set of 25 dots as quickly as possible while maintaining accuracy. In Part A, the targets are all numbers from 1 to 25, the participants were instructed to connect them in sequential order. In Part B, the dots go from 1 to 13 and include letters from A to L. The participant was instructed to connect them in sequential order while alternating letters and numbers, as in 1-a-2-B-3-C., in the shortest time available. The scoring of results for both TMTs A and B were reported as the number of seconds required to complete the task; therefore, higher scores revealed greater impairment. For the TMT A, the average test scores were 29 seconds and >78 seconds was recorded as impairment. As well for TMT B, 75 seconds is the average score and >273 seconds was recorded as impairment. The validity and reliability of this tool among the obese population have been confirmed in previous studies [34,35].

### 2.3. Study procedure

All the participants who volunteered and met the study criteria took part in the experiment. Each participant undertook a pre-intervention assessment, which included a cognitive assessment where each participant was given a copy of TMT A and a pen or pencil. The researcher then demonstrated the test to the participant using a sample sheet (TMT A-SAMPLE) after which the participant did the test. The researcher timed each participant as they followed the 'trail' made by the numbers on the test. The time spent is recorded in seconds and the procedure is repeated for TMT Part B.

Another pre-intervention assessment was the static balance test using the unilateral pedal tests (Unilateral pedal eyes open [UPEO], and Unilateral pedal eyes close [UPEC] tests). The process involved each participant determining their dominant lower limb and the researcher demonstrated the test with hands crossed over the chest, standing on the dominant limb, starting with the eyes open and alternating it with the eyes closed tests. The researcher timed each participant as they lifted the subordinate leg off the floor, and the UPEO and UPEC in alternating manner after 10 minutes of rest between each. The time spent with the subordinate leg sustained in the air is recorded and the procedure was done 3 times for each participant recording values of UPEO1, UPEC1, UPEO2, UPEC2, UPEO3, UPEC3.

The third pre-intervention assessment was measuring dynamic balance using the 3 Meter Backward Walk Test (3MBWT). Backward walking is crucial for everyday activities like backing up to a chair, navigating through crowded spaces, opening doors, and avoiding sudden obstacles [36]. The procedure involved the researcher using a firm measuring tape to measure 3 meters on level ground. The researcher then demonstrates on the test starting with the tip of the heel on the same line as the 3-meter mark. The researcher recorded the time spent by each participant walking backward as fast as possible through the 3 meters while maintaining a straight line.

In the intervention phase, the participants were coming to the gym 3 times a week for rebound exercise. The time for exercise was 30 minutes per session with three intermittent stops every 10 minutes, with rest for up 2 minutes before continuing till the 30 mins. After the first two weeks, the participants who had good tolerance to the rebounding exercise had their time progressed to 45 minutes per section. All participants completed the sessions for six weeks. For the post-test assessment, all the pre-intervention assessments were repeated after 3 weeks and 6 weeks following the exercise intervention.

### 2.4. Data analysis

Descriptive statistics of mean and standard deviation were used to summarize data. The normality test revealed that the 3-meter backward test scores were not normally distributed and thus were analyzed using the Friedman test. The other data were analyzed using one-way within-groups analysis of variance (ANOVA) to make comparisons across variables measured at the 3-time points during the study. Data was analyzed using SPSS version 23 (Illinois, Chicago) at $p$ values set at 0.05.

## 3. Results

This This study included 20 female students with overweight and obese, mean age, weight, height, and BMI of 20.2 ± 3.0 years, 83.4 ± 9.6 kg, 1.6 ± 0.17meters, and 31.9 ± 3.3 kg/m2 respectively as presented in Table 1.

Table 2 shows the comparisons of participants' cognitive functions across weeks 1, 3, and 6. There was a significant difference ($p < 0.001$) in the participants' TMT A values and TMT B values across weeks 1, 3, and 6 with a progressive decrease in the test time.

A Bonferroni post hoc analysis presented in Table 3 for TMT A and TMT B were similar as they showed a significant difference between weeks 1 and 3 ($p < 0.001$); weeks 1 and 6 ($p < 0.001$); and weeks 3 and 6 ($p < 0.001$).

Table 4 presents comparisons of participants' unilateral pedal test and 3MBWT values across weeks 1, 3, and 6. There was a significant ($p < 0.05$) difference in the participants' UPEO values and 3MBWT values across weeks 1, 3, and 6 with a progressive increase over time. However, no significant difference ($p = 0.544$) was found in the participants' UPEC values across weeks 1, 3, and 6.

Table 5 shows that the performance in the UPEO and 3MBWT with training was similar, given that significant differences were seen between weeks 1 and 3

**Table 1.** Participants' general characteristics ($n = 20$).

| Variable | Mean ± standard deviation | Minimum | Maximum |
|---|---|---|---|
| Age(years) | 20.2 ± 3.0 | 17.0 | 25.0 |
| Weight(kg) | 83.4 ± 9.6 | 69.0 | 99.0 |
| Height(m) | 1.6 ± 0.17 | 1.58 | 1.7 |
| BMI(kg/m2) | 31.9 ± 3.3 | 26.53 | 38.0 |

BMI= Body Mass Index; kg= kilogram; *m*= meters.

**Table 2.** Comparisons of participants' cognitive performances across weeks 1, 3 and 6.

| Variable | Week 1 | Week 3 | Week 6 | F-value | P-value |
|---|---|---|---|---|---|
| TMT A(sec) | 24.5 ± 8.0 | 21.2 ± 7.6 | 19.2 ± 7.3 | 53.268 | <0.001* |
| TMT B(sec) | 70.7 ± 19.9 | 51.7 ± 16.8 | 47.6 ± 15.6 | 25.285 | <0.001* |

TMT A= Trail Marking Test A; TMT B= Trail Marking Test B; * indicates significance at $p < 0.05$.

**Table 3.** Bonferroni post-hoc analysis showing pairwise comparisons across the three weeks.

| Variables | Week 1 | Week 3 | Week 6 |
|---|---|---|---|
| **TMT A** | | | |
| Week 1 | | <0.001* | <0.001* |
| Week 3 | | | <0.001* |
| **TMT B** | | | |
| Week 1 | | <0.001* | <0.001* |
| Week 3 | | | 0.003* |

TMT A= Trail Marking Test A; TMT B= Trail Marking Test B; * indicates significance at $p < 0.05$.

($p = 0.038$); weeks 1 and 6 ($p = 0.011$), whereas no differences were detected between weeks 3 and 6 ($p = 1.000$).

## 4. Discussion

This study set out to determine the effect of rebound exercise on cognition and balance among females with overweight and obesity. The results showed significant changes in the cognitive test, static and dynamic balance after 3 and 6 weeks of rebound exercise trial.

Results from the Trail Marking Tests A and B suggest that rebound exercise significantly improved the cognitive function of the participants as the time taken to complete the test decreased progressively from baseline. This progressive decrease in the time taken to complete the TMT tests following rebound exercise indicates an enhanced cognitive performance, particularly in the domains of attention, processing speed, and cognitive flexibility which is the ability to switch between different cognitive tasks. Remarkably, the increased cognitive performance was observed as early as three weeks of rebound exercise training and it continued to improve as the weeks progressed. These results corroborate the findings of several studies that have reported improvement in cognitive function among various populations like untrained high school children [37], physically active adults [38], individuals with traumatic brain injury [39], and stroke survivors [40] following aerobic exercise. Like other plyometric exercises, rebound exercise is thought to enhance cognitive functioning through several mechanisms including improving cerebral blood flow, stimulating the production of brain-derived neurotrophic factor associated with neuroplasticity, releasing stress-reducing mood-enhancing endorphins and protecting the brain from inflammatory changes [41,42]. This increased circulation is crucial as it ensures that the brain receives more oxygen and nutrients, essential for optimal cognitive performance [43–45]. Furthermore, rebounding's rhythmic and dynamic nature can stimulate various sensory systems, enhancing motor skills, balance, and coordination [46]. These physical improvements are closely linked to cognitive processes since activities that require coordination and balance also engage brain areas responsible for these functions [47]. Moreover, rebound exercise as an aerobic exercise increases endorphin release, improves mood, and reduces stress and anxiety. Reducing stress and enhancing mood can create a more favourable environment for cognitive functioning. Additionally, the repetitive bouncing motion involved in rebounding can enhance neural connectivity between different brain parts, potentially leading to improved cognitive function.

Another important finding of this study is that rebound exercise led to significant improvements in the static balance of females with overweight and obesity. A significant increase in unilateral stance

**Table 4.** Comparisons of participants' unilateral pedal tests and 3MBWT values across weeks 1, 3 and 6.

| Variable | Week 1 | Week 3 | Week 6 | F-value | $X^2(2)$ | P-value |
|---|---|---|---|---|---|---|
| UPEO(sec) | 20.7 ± 11.9 | 34.9 ± 25.4 | 35.4 ± 22.2 | 7.010 | – | 0.011* |
| UPEC(sec) | 2.7 ± 1.7 | 2.8 ± 1.6 | 3.0 ± 1.5 | 0.643 | – | 0.544 |
| 3MBWT | 4.9 ± 2.3 | 3.8 ± 0.9 | 3.4 ± 0.9 | – | 9.776 | 0.004* |

UPEO= Unilateral Pedal Eye Open Test; UPEC= Unilateral Pedal Eye Close Test; 3MBWT = 3 Meters Backward Walk Test; * indicates significance at $p < 0.05$, $X^2(2)$-Chi-squared test (degree of freedom).

**Table 5.** Wilcoxon signed-rank test for pairwise comparisons with Bonferroni correction across the three groups.

| Variable | Week 1 | Week 3 | Week 6 |
|---|---|---|---|
| **UPEO** | | | |
| Week1 | | 0.038* | 0.011* |
| Week 3 | | | 1.000 |
| **3MBWT** | | | |
| Week1 | | 0.018* | 0.000* |
| Week3 | 0.018* | | 0.093 |

UPEO= Unilateral Pedal Eye Open Test; 3MBWT = 3 Meter Backward Test; * indicates adjusted significance by the Bonferroni correction with $p < 0.05$.

time was observed between baseline and week 3, and between baseline and week 6. However, no further significant improvement was detected between weeks 3 and 6, suggesting that the most substantial gains in balance performance occurred early in the intervention. The lack of significant improvement in later weeks may indicate a period of adaptation where further gains were smaller and less detectable, rather than a true plateau or ceiling in performance. Although this finding differs from a recent study [30], it is largely consistent with previous works on the effect of rebound exercise on static balance in diverse populations. For instance, Sisi et al. [48] and Sadeghi et al. [49] reported improved static balance following rebound exercise training in individuals with multiple sclerosis and spinal cord injury respectively. Similarly, rebound exercise was also found to increase static balance and stability among athletes and young boys [50,51]. This study further found that participants showed a significant increase in unilateral stance time when their eyes were open, but not when their eyes were closed. This could be because having their eyes open allowed them to visually monitor their body position and make real-time adjustments, leading to better balance control. Alternatively, it's possible that rebound exercise may not have had a strong direct effect on the vestibular and somatosensory systems that are involved in postural control, but its impact on the visual system might be a key factor. The need to constantly adjust one's position while bouncing could enhance visual-motor integration and proprioceptive feedback, thereby indirectly improving balance [22]. The exercise's demand for maintaining balance on an unstable surface may particularly stimulate the visual system more than the vestibular or somatosensory systems, as participants rely heavily on visual cues to maintain stability [52]. This reliance on visual input could explain why rebound exercise might predominantly impact the visual component of postural control.

Perhaps the most clinically relevant finding of this study is the significant increase in dynamic balance among females with overweight or obesity following rebound exercise. This result reflects those of other studies that reported improvement in dynamic balance and mobility of healthy individuals and those with neurological disorders after rebound exercise training [22,30,45]. The studies have shown that there was a noticeable improvement in dynamic balance and mobility between 3 weeks and 12 weeks indicating a relatively rapid response to rebound exercise. The repetitive bouncing done during rebound exercise requires constant adjustments in muscle activation and joint positioning to maintain balance on the unstable trampoline surface [53]. This process stimulates the vestibular system, enhances proprioception and neuromuscular control, and strengthens lower limb muscles resulting in better dynamic balance. The results of the 3-meter backward test showed that there was a gradual decrease in the time it took to complete the test between the baseline and 6 weeks. This suggests that there was an improvement in mobility, especially in walking backward, which reduced the risk of falling and enhanced coordination and balance in the lower limbs. This finding is particularly relevant for individuals with overweight or obesity who may face additional mobility challenges.

## 5. Limitation

This study's notable limitations include selection bias in recruiting the participants and the relatively small sample size of the study may limit the generalizability of the findings. The lack of a control group also makes it difficult to account for confounding variables and limits the ability to draw a definitive conclusion on cause and effect. Additionally, the Trail Making Test Apparatuses (TMT) used as the primary outcome to measure cognitive performance may have a possible weakness due to a learning factor that might improve the performance of the participants by repetition. Finally, the short duration of the study does not allow for assessing the long-term effects and sustainability of the observed effects of rebound exercise on cognition and balance. Nevertheless, this study adds novel findings on the use of rebound exercise to improve cognition and balance in this population.

## 6. Conclusions

Rebound exercise has shown promise in improving the cognitive performance and balance of females with overweight or obesity. While the study provides preliminary insights into the potential benefits of rebound exercise for females with overweight or obesity, it's important to interpret the conclusions with caution. Given that the population in this study was relatively young and healthy; being within normal ranges of cognition and balance in their baseline, future research with improved study designs and longer duration among bariatric older adults will contribute to a more comprehensive understanding of the effects of rebound exercise on dynamic balance and cognitive function.

## Disclosure statement

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## Author contributions

The study conception and design were carried out by Ojukwu CP, Okemuo AJ, and Nnyaba IS; Material preparation, data collection and analysis were performed by Ede SS, Enebe JA, and Nnyaba IS. The first draft of the manuscript was written by Ede SS, Ojukwu CP, and Okemuo AJ. All authors commented on previous versions of the manuscript. All authors read and approved the final manuscript.

## Availability of data and materials

The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.

## Ethics approval and consent to participate

The study's design, potential hazards, and associated discomfort were communicated to the participants, who then provided written informed consent prior to enrolment. The study was approved by the Health Research and Ethics Committee of the University of Nigeria Teaching Hospital, Ituku-Ozalla, Enugu State [ethics approval no: NHREC/05/01/2008B-FWA00002458-1RB00002323] and it was conducted according to the recommendations in the Declaration of Helsinki.

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