

Article

A proposal concerning exercise intensity with the Nintendo Ring Fit Adventure Exergame among older adults: A preliminary study

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Abstract

The Nintendo Ring Fit Adventure (RFA) (Nintendo, Kyoto, Japan) is a novel exergame that combines exercise and video game elements. Although previous RFA intervention studies have reported the health effects of the RFA, exercise intensity among older adults has not yet been documented. We hypothesized that the exercise intensity of older adults in the current RFA setting may be low. This preliminary study developed a range of prototype RFA intensity conditions and to evaluate exercise intensity among older adults. Six older adults (1 male/5 females, mean age 75.2±10.3 years old) participated in this study. Three RFA conditions were developed: "LOW" (the 'default' load. Older individual input actual gender and age), "MODERATE" (as defined by the American College of Sports Medicine [ACSM]: 40%-59% heart rate reserve [HRR]), and "HIGH" (highest exercise intensity that older individuals could set in the game). Exercise intensity was assessed using the %HRR. The results show that the %HRR values for the conditions were 34.9%±4.1% (LOW), 40.0%±2.9% (MODERATE), and 52.3%±3.1% (HIGH). In conclusion, this preliminary study showed that, among the three prototype RFA conditions, both MODERATE and HIGH conditions generally attain moderate or greater intensity for older adults when assessed using the heart rate.

Keywords: video game, heart rate, Exergame, validation

1. Introduction

The Ring Fit Adventure (RFA) (Nintendo, Kyoto, Japan) is a novel exergame (Benzing & Schmidt, 2018) that combines exercise and video game elements. Unlike traditional video games, which primarily involve fingertip operation, exergames require significantly higher energy consumption than the resting state. Compared to existing exergames, the RFA uniquely combines gameplay and exercise through the incorporation of strong role-playing game elements, enabling the protagonist's growth within the game.

Launched in 2019, the RFA achieved substantial sales in 2020, largely due to the COVID-19 pandemic and related closures of gyms and other exercise facilities. As of 2023, the RFA has sold over 15 million units worldwide (Nintendo, IR Infomation). Exergames are recognized for their entertainment value and motivational potential, attracting attention as a new approach to improving health, especially among older adults (Nagano et al, 2018). Previous systematic reviews have reported improvements in the cognitive function and balance resulting from exergame use in older populations (Stojan et al, 2019; Liu et al, 2022). While two intervention studies on the RFA have already demonstrated significant health-promoting effects, including improvements in back pain among patients with chronic back pain (Sato et al, 2021) and enhanced physical fitness in university students (Wu et al, 2022), further research is warranted to assess the health benefits of the RFA in older adults.

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Taking into account the fact that very few studies have so far been published on RFA, whether or not the exercise intensity settings in the RFA are actually appropriate for users, including older populations, remains uncertain. On the game setting screen in the RFA, users can adjust the exercise intensity (load) from 1 (weakest) to 30 (strongest) (Nintendo, Q&A). Unfortunately, older users following game instructions can only select slightly lower intensity exercises due to age-based load limits that are set conservatively for older adults. In addition, the exercise intensity algorithm used in the RFA is confidential, leading to ambiguity concerning the exercise intensity setting.

Although not directly related to the RFA, the existing literature provides limited guidance on exercise intensity settings in exergames. These previous studies (Sato et al, 2021; Wu et al, 2022) referred to exercise intensity in different exergames (Wii Fit and Wii Sports, Nintendo). For instance, Wu et al. (2022) described the RFA exercise intensity as follows: ‘Although the amount of exercise depends on the specific exercise intensity chosen by the player, it is generally set at 4 to 6 metabolic equivalents (METs)’ (Wu et al, 2022). A previous study found that the exercise intensity of Wii Sports is between 3 and 5 METs (Miyachi et al., 2010). However, this citation by Ainsworth et al. (Ainsworth et al, 2000) pertains to the METs of exergames unrelated to the RFA. Consistent with these previous studies (Ainsworth et al, 2000; Miyachi et al, 2010), it has been shown that the mean exercise intensity of the Wii Fit was 3.2 ± 0.6 METs.

However, while these RFA intervention studies have reported some health effects (Sato et al, 2021; Wu et al, 2022), the exercise intensity in the RFA has not been documented. Consequently, the appropriateness of assuming the same intensity range for the RFA (4-6 METs) remains uncertain. Given the lack of specific evidence regarding the RFA exercise intensity settings in older adults, it is crucial to meticulously examine this issue.

Considering the aforementioned limitations observed in previous RFA studies (Sato et al, 2021; Wu et al, 2022), the current preliminary investigation sought to evaluate the suitability of exercise intensity in the RFA for older adults. To this end, we designed and implemented a diverse set of prototype RFA intensity conditions and assessed the exercise intensity experienced by older adults during each condition using the heart rate (HR) as a metric. Consequently, the primary objective of this preliminary study was to identify and propose an appropriate RFA intensity setting tailored to the needs of older adults.

2. Methods

2.1. Participants

The participants in this study were community-dwelling older adults residing in Matsue City, Shimane Prefecture. They were members of a community health class for older adults, which was overseen by a faculty member at Shimane University. This study was conducted using flyers and telephone calls. The inclusion criteria were as follows: 1) individuals ≥ 60 years old and 2) those who had not participated in any other exercise program in the previous 6 months. The exclusion criteria were as follows: 1) difficulty performing standing exercises involving bending and extending the knees, 2) resting systolic blood pressure of ≥ 180 mmHg, 3) contraindicated for exercise by a family physician, and 4) any other criteria considered inappropriate by the investigator. This study was approved by the Research Ethics Committee of the Faculty of Human Sciences of Shimane University (2022-3).

2.2. The RFA (Fig. 1)

The RFA incorporates the use of the Ring-Con and Leg-Band, which are equipped with built-in gyro sensors and acceleration sensors, thus enabling the detection of subtle human movements (Nintendo, Frequently Asked Questions about Ring Fit Adventure). There are two main types of exercise approaches with the RFA: "The Easy Mode," featuring mini-games, and "The Adventure Mode". We used the Adventure Mode, as described in previous studies (Sato et al, 2021; Wu et al, 2022). The Adventure Mode primarily involves aerobic exercises, such as jogging, and resistance exercises. During aerobic exercise, the leg band, affixed to the thigh, detects movements (acceleration), such as jogging, and the avatar on the game screen replicates this jogging activity. In battle scenes, the player is instructed to perform certain exercises, such as gripping the Ring-Con tightly, tilting it to the left or right, or squatting. By following these instructions, the player can effectively defeat enemies. Throughout the game, a combination of jogging and battles contributes to the player's progress and advancement in different stages (Fig. 1).

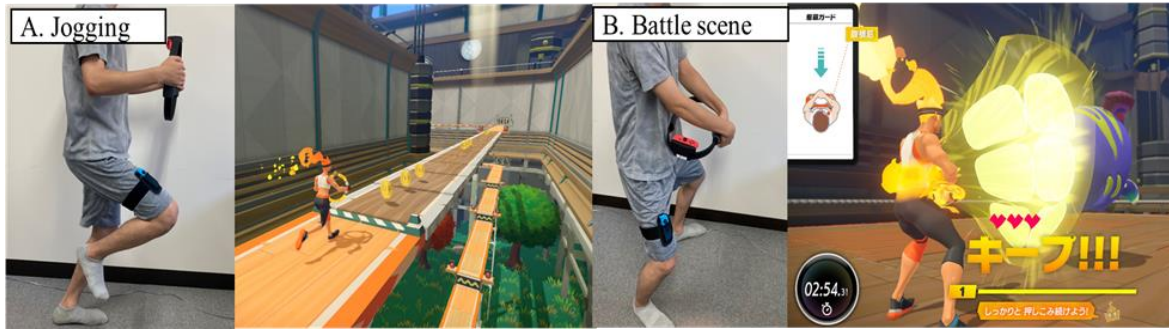
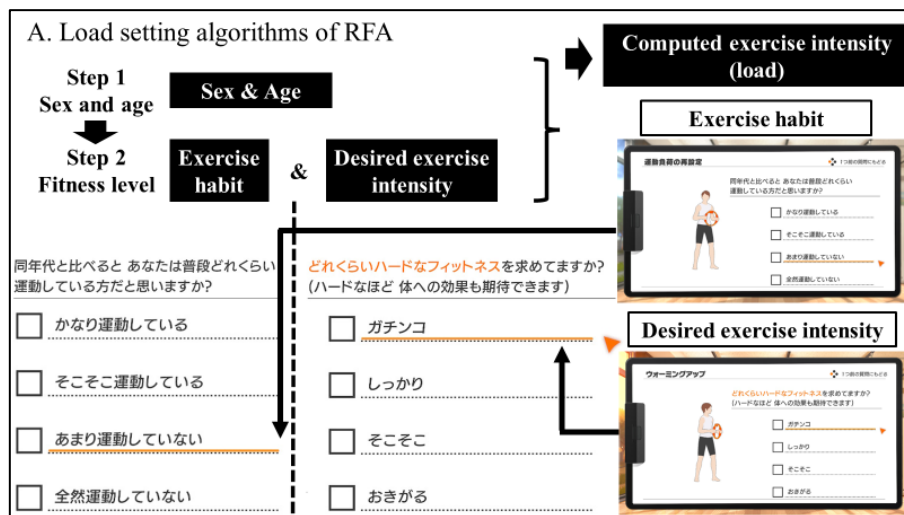


Fig. 1. Illustration of the RFA manipulation. A) Jogging and B) the battle screen.

2.3. Setting the exercise intensity with the RFA (Fig. 2AB)

With the RFA, users can freely select their exercise intensity according to their age, physical fitness, and desired exercise intensity (Fig. 2A). The exercise intensity setting in the RFA is determined using an algorithm developed by the manufacturer (Nintendo) and is executed as follows: during the initial screen setup, users input their age and sex (Step 1). Thereafter, the users input their exercise habits and desired exercise intensity (load) (Step 2). Based on these two steps, the load level (1-30) was determined automatically on a scale from 1 (weakest) to 30 (strongest). As the load level (1-30) increases, users are required to exert greater force on the Ring-Con to defeat enemies and perform more vigorous leg movements (e.g. jogging) to trigger responses from the leg band (the leg band response threshold adjusts accordingly). Specifically, young individuals (<65 years old) could choose any load level from 1 to 30 (e.g. load set to 21, as shown in Fig. 2B). However, for older adults (≥65 years old), the intensity choices are limited, as the system sets the maximum load setting to 15 or lower by default in this age group (refer to Table 1). Consequently, if an older individual selects a general setting (Options around the middle row in ‘Exercise habit’ and ‘Desired exercise intensity’), the RFA load will often be set very low, at approximately 3-5 (equivalent to low-intensity exercise for a middle-aged person, such as the lowest row in Fig. 2A) in most cases.



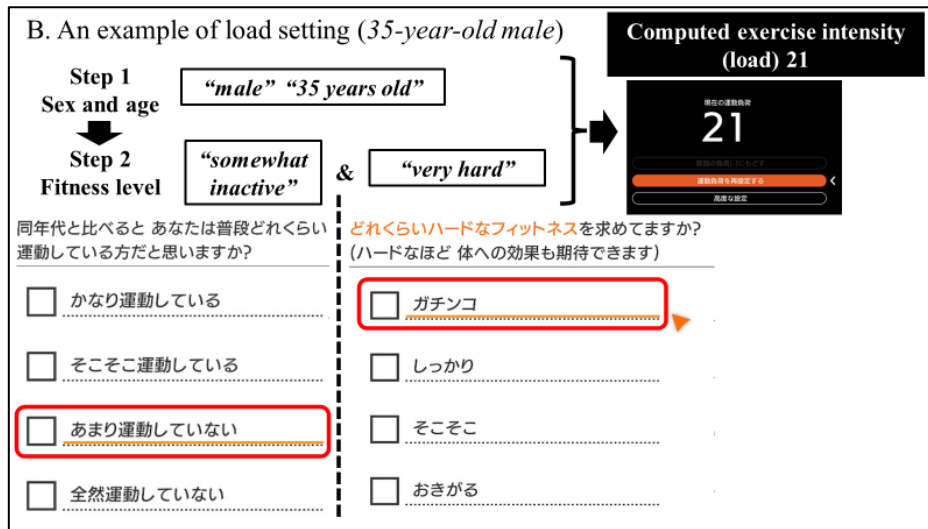


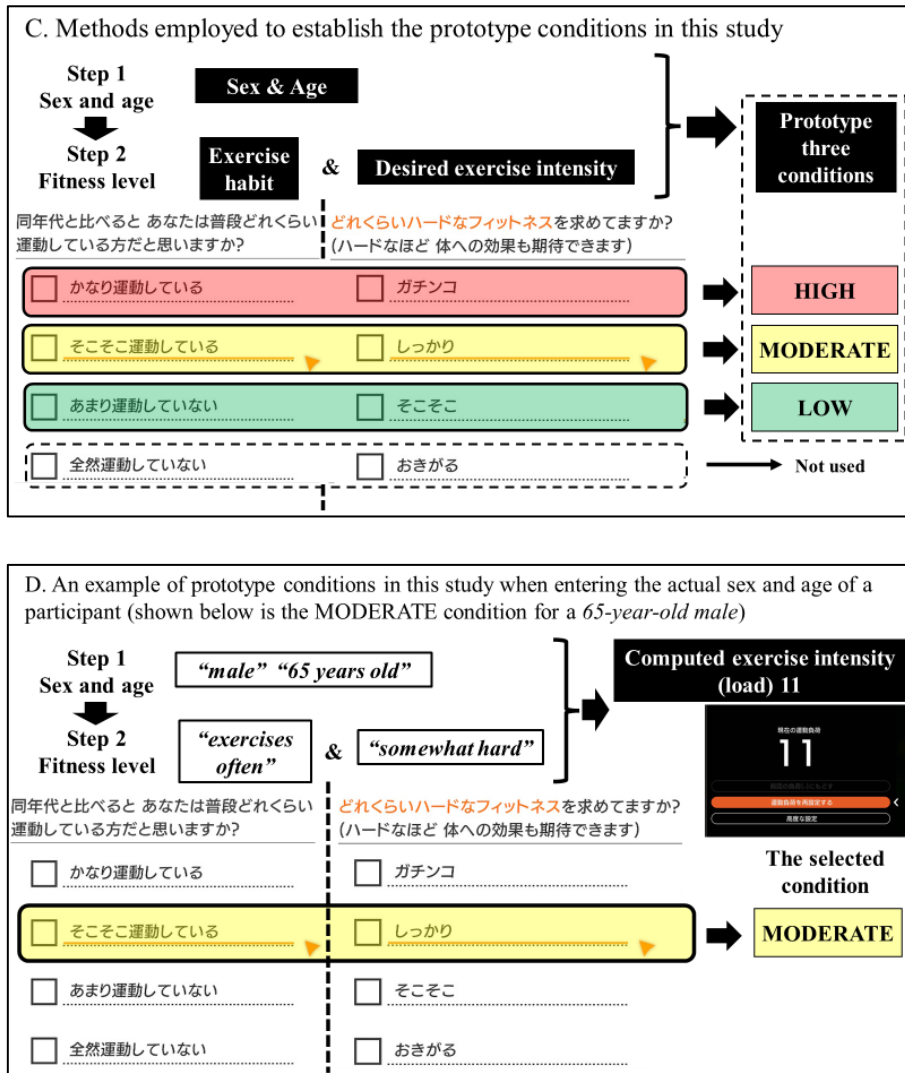
Fig. 2. The RFA load setting screen. A) Load setting algorithms of the RFA provided by the manufacturer. B) An example of a load setting for a 35-year-old male who chose an exercise habit of "somewhat inactive" and a desired exercise intensity of "very hard". In this case, the RFA automatically set the load to '21'.

2.4. Study design

2.4.1. Experimental conditions (Table 1, Fig. 3CD)

In the present study, we established three intensity conditions of LOW, MODERATE, and HIGH. Fig. 2C illustrates the setup of the conditions used in our investigation. We hypothesized that the MODERATE condition would correspond to moderate intensity as defined by the American College of Sports Medicine (ACSM) (ACSM, 2018), based on the following rationale: first, we set the LOW condition (the 'default' load) to represent the general intensity of older players (≥ 65 years old). To achieve this, we incorporated the actual gender and age of the older participants, resulting in a load of approximately 3-5, as shown in Table 1. Second, the HIGH condition was configured to represent the highest intensity suitable for older players (≥ 65 years old) in the RFA setting. We assumed that the HIGH condition would elicit a vigorous intensity ($\geq 60\%$ heart rate reserve [HRR]). Finally, the MODERATE condition was determined as an intermediate level between the LOW and HIGH conditions, targeting moderate intensity (40%-59% HRR) (ACSM, 2018).

To assess these conditions, two researchers (TO and DF) conducted preliminary playing tests. During these tests, they entered the age and sex of older players and set the load (1-15) accordingly. The HR and rating of perceived exertion (RPE) were recorded during preliminary tests. While configuring the load in the RFA, various combinations were available based on the options of "exercise habit" and "desired exercise intensity" (Fig. 2A). For ease of testing, we selected convenient combinations of "exercise habit" and "desired exercise intensity" within the same row (Fig. 2CD). Notably, the combination with the lowest intensity ("inactive" \times "very light") was excluded because it had the lowest load (1) (Fig. 2C).



(Continued) Fig. 2. C) Methods employed to establish the three prototype conditions used in this study. Although any combination could be selected (restricted to 1-15 for older individuals), for simplification purposes, only combinations in the same row were utilized in this study. The LOW condition was the ‘default’ load for older individuals (when an older individual input their actual gender and age). Note that the weakest combination was not utilized because it resulted in a load set to 1 (the lowest level), which was deemed unsuitable. D) An example of the prototype conditions in this study (MODERATE condition for a 65-year-old male).

Table 1. Conditions and exercise intensity (load)

Conditions	Age (years)		
	65-69	70-79	≥80
HIGH	15	12	9
MODERATE	11	8	5
LOW	5	4	3

Table Footnote: Values presented are for males. For females, all values are adjusted to 1 less than the male values. It is important to note that all values, including age groups and load values, are derived from the RFA setting screen. Although guidance regarding how to adjust the loads is available from the manufacturer (Nintendo, Q&A), the details regarding the load settings algorithms have not yet been disclosed. Therefore, the values displayed are based on preliminary tests conducted by the two researchers before the commencement of the present study. Please refer to Fig. 2 for detailed information on how the conditions were configured.

2.4.2. Experiments and measures

Upon arrival at the designated venue, the participants were instructed to rest for at least 30 min before engaging in RFA play under the three conditions (LOW, MODERATE, and HIGH) in a predetermined order (from LOW, MODERATE, to HIGH). Participants played under each condition for approximately 30 min, with a break of at least 30 min between conditions. The load for each condition was determined by inputting the participants' actual "gender" and "age" into the RFA setting screen.

During RFA play, HR measurements were taken, including the resting HR and HR every 30 s during exercise. In addition, the RPE was recorded immediately after the completion of each condition. Consistent with a previous study (Onishi et al, 2022), the participants wore a Polar OH1 heart rate monitor (Polar Electro Inc., Bethpage, NY, USA) on their upper arms. HR data were transmitted to the Polar Team application on a tablet device (Polar Electro Inc.) for recording.

The exercise intensity was evaluated by converting HR measurements (every 30 s) to the %HRR. Following the ACSM guidelines (ACSM, 2018), exercise intensity based on the %HRR was categorized as follows: low-intensity (<40% HRR), moderate-intensity (40%-59% HRR), and vigorous-intensity (\geq 60% HRR). The participants' maximum HR was estimated using the formula "220 – age" (Fox et al, 1971).

2.5. Statistical analysis

Continuous data were presented as the mean \pm standard deviation (SD). For the HR, the data were derived from the actual time spent exercising (jogging and battle scene) from the beginning to the end of the exercise session. HR measurements obtained during simple standing and waiting periods, such as during the RFA tutorial screen, were excluded from the dataset.

3. Results

The study included 6 older adults (1 male and 5 females) with a mean age of 75.2 ± 10.3 (range, 63–88) years old and a body mass index (BMI) of 21.6 ± 2.2 kg/m². Fig. 3A-C illustrates the HR changes (%HRR) during the experiment for these six participants. The mean %HRR values for the 3 conditions were as follows: $34.9 \pm 4.1\%$ (LOW), $40.0 \pm 2.9\%$ (MODERATE), and $52.3 \pm 3.1\%$ (HIGH) (Fig. 4). In addition, the RPE values were 12.7 ± 2.3 (LOW), 13.7 ± 1.2 (MODERATE), and 14.4 ± 2.6 (HIGH).

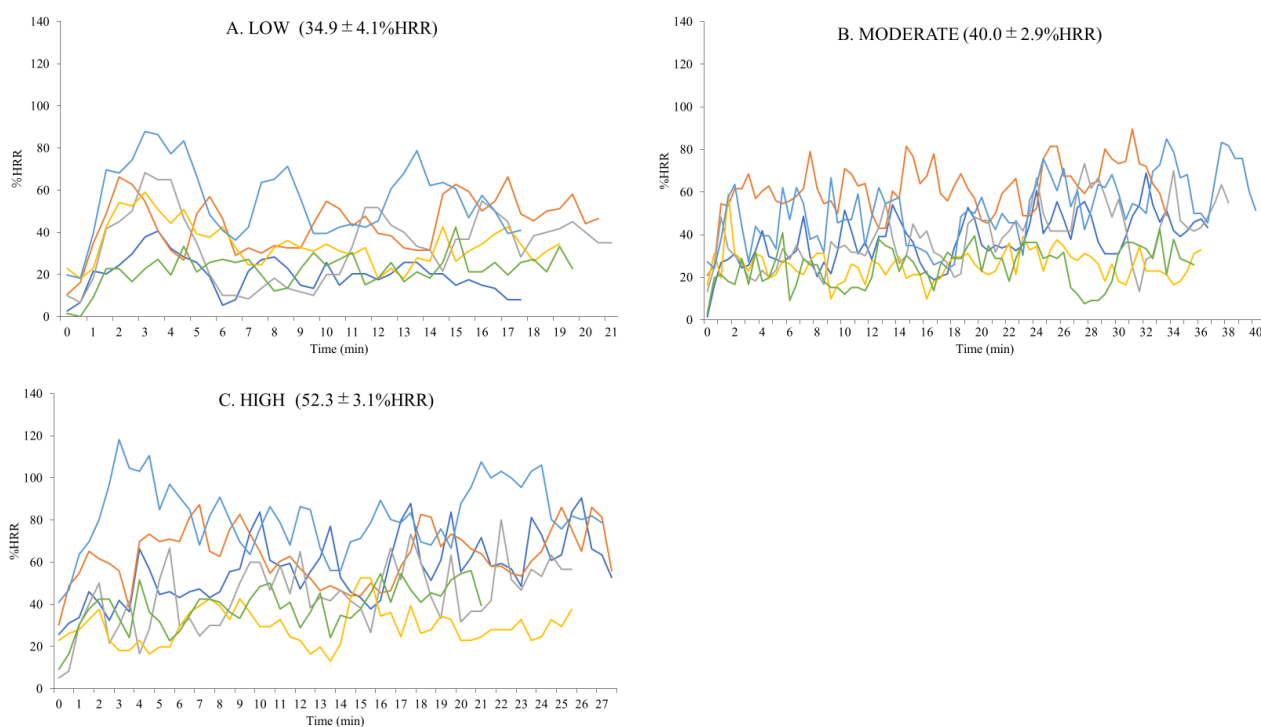


Fig. 3. The %HRR in each condition. The lines show the changes in HR for each participant.

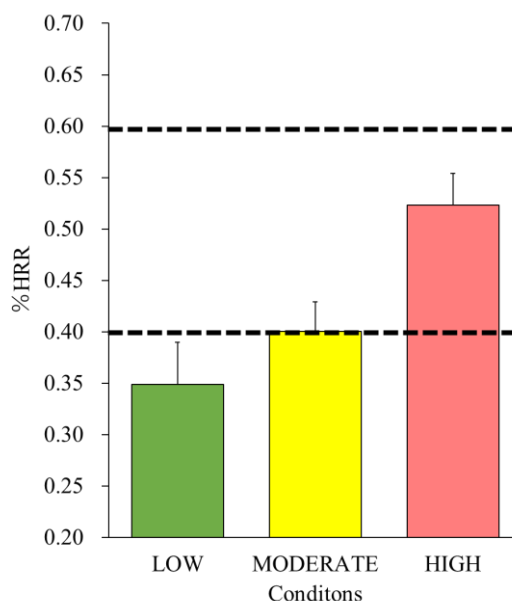


Fig. 4. Average %HRR for each condition. The dashed lines indicate moderate intensity (40%-59% of HRR) as defined by the American College of Sports Medicine. (ACSM, 2018)

4. Discussion

We investigated the HR responses of older adults under our prototype RFA intensity conditions. As anticipated, the MODERATE ($40.0\% \pm 2.9\%$ HRR) and HIGH ($52.3\% \pm 3.1\%$ HRR) conditions achieved moderate intensity (40% - 59% of HRR) and were deemed suitable for older adults. Given that moderate or vigorous exercise intensity is necessary to attain cardiovascular health benefits (such as enhanced cardiorespiratory fitness and reduced blood pressure) (Garber et al, 2011), it is plausible that the current RFA load might be somewhat low. However, the details concerning the manufacturer's intensity-setting algorithm remain unclear. Of note, although the exercise load under HIGH conditions was at the heaviest setting for older individuals offered by the RFA, the intensity ($52.3\% \pm 3.1\%$ HRR) did not reach a vigorous intensity level ($\geq 60\%$ HRR). This means that older individuals may not be able to enjoy vigorous intensity exercise with the current RFA settings. These upper limits for older individuals might be set by the manufacturer, due to dangers associated with possible adverse health events caused by too heavy of a load. Consequently, if older users intend to improve their physical fitness, it may be advisable to utilize established and validated exercise intensity indices (e.g. HR and RPE) while also referencing the intensity settings offered by the RFA.

Several limitations associated with the present study warrant mention. First, the sample size was relatively small. Therefore, our findings should be confirmed in a larger study population. Second, our study participants were community-dwelling older volunteers and might have been more physically healthy than the general elderly population. Third, loads ≥ 16 were not used in this study. This was because the RFA settings did not provide loads of ≥ 16 for older users (only load 1-15 were selectable). In addition, the prototype MODERATE and HIGH conditions were subjectively determined by two researchers based on their own HR, RPE, and other subjective indicators of exercise intensity. Although our findings indicated differences in the %HRR among the three conditions, a more objective condition setting would have been desirable. For instance, validating all 30 RFA load settings (1-30) would have been preferable, but the burden on both the examiner and examinee made this impractical. Fourth, the exercise duration for each condition varied in our study. For instance, the LOW condition was terminated at the examiner's discretion owing to the ease of the task and reduced participant motivation, while some participants were unable to complete the HIGH condition because of its high intensity. Although duration discrepancies were present, we deemed it necessary to ensure the safety of our older participants.

5. Conclusions

This preliminary study of older adults indicates that, among the three RFA exercise intensity conditions set in this investigation, both the MODERATE and HIGH conditions generally achieve moderate or greater intensity. Given these findings, it is recommended that, based on our phenotype conditions, older individuals should use established and validated exercise intensity indices (e.g. HR and RPE) while also considering the intensity settings offered by the RFA. Future studies should investigate the long-term health effects of interventions based on the RFA intensity settings proposed in this study.

Author Contributions

Conceptualization, T.O., R.M.; methodology, T.O., D.F.; software, T.O., D.F.; validation, D.F.; formal analysis, T.O.; investigation, T.O., D.F., R.M.; resources, R.M.; data curation, T.O. and R.M.; writing—original draft preparation, T.O. and R.M.; writing—review and editing, T.A.; visualization, T.O.; supervision, T.A. and R.M.; project administration, R.M.; funding acquisition, R.M.

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Institutional Review Board Statement

This study was approved by the Research Ethics Committee of the Faculty of Human Sciences of Shimane University (2022-3).

Informed Consent Statement

Informed consent was obtained from all participants involved in the study.

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Conflicts of Interest

The authors declare no conflict of interest.

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