JPAIR Multidisciplinary Research Volume 51 (January 2023)
DOI: https://doi.org/10.7719/jpair.v51i1.675

Enhancing Muscular Strength with Resistance and High-Intensity Interval Training Using a Fitness Mobile App Guide

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Originality: 100% • Grammarly: 98% • Plagiarism: 0%

ABSTRACT

Article history:

Received: 15 Aug 2022
Revised: 20 Sept 2022
Accepted: 26 Jan 2023

Keywords — Health Science, muscular strength, HIIT, strength training, technology-based mobile apps, quasi-experimental, Philippines

Physical educators face the challenge of adapting how their classes are perceived to address student health and physical inactivity. The study aimed to enhance the health-related fitness component of muscular strength with strength training and high-intensity interval training (HIIT) based on the program provided by a mobile application. The study employed a quasi-experimental research design that accommodated 20 female participants in Group 1, the strength training group, and 17 female participants in Group 2, the HIIT group. After the participants recorded their scores in the pretest using the standard push-up test, they were exposed to their assigned intervention programs using the mobile app as their

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guide. The post-test followed the same testing procedure as the pretest. Findings reveal that the female participants performed moderately in the standard push-up test, both in the pretest and post-test. The post-test scores of the strength training group differed significantly from their pretest results, indicating that the training effectively enhances muscular strength. On the other hand, the HIIT group did not significantly differ, implying that there is no sufficient evidence in the claim that HIIT significantly improves muscular strength. The finding further reveals that strength or resistance training is more effective in enhancing muscular strength. Thus, researchers can conduct a further empirical investigation to determine how effective HIIT is in enhancing muscular strength, considering the gender, age, and skill level of the research participants.

INTRODUCTION

Health-related fitness is a multi-dimensional paradigm comprising cardiorespiratory endurance, muscular strength, endurance, flexibility, and body composition (Britton et al., 2020). Among the five fitness components, the researcher concentrated on muscular strength based on a systematic review providing evidence that improving muscular strength enhances essential aspects of health, including low back pain, increasing movement control, improving cardiovascular health, and body composition, among others (Westcott, 2012). Muscular strength is one of the components of physical fitness defined as the ability to impart force to an external object or resistance. Depending on the demand of a strength task, the performance of muscular strength for every individual is relative. They may exert significant forces against gravity to manage their body, manipulate their body mass plus an opponent's body, or handle an object or projectile (McGinnis, 2013).

Moreover, in recent years, mobile apps have become increasingly popular for exercise training, including high-intensity interval training (HIIT) and resistance training. For example, a study by Akcan et al. (2020) investigated the effects of HIIT on body composition and muscular strength in combat athletes, while Alsairawan et al. (2019) examined whether a 2-week calisthenics HIIT program is sufficient to improve aerobic and anaerobic capacity. These studies suggest that HIIT is an effective intervention for improving muscular fitness.

Similarly, research has shown that using mobile apps for resistance training can enhance muscular strength and fitness. Gollie et al. (2020) compared the effects of a 12-week resistance training program using a mobile app with traditional gymbased training in young adults. They found that both interventions significantly improved muscular strength and body composition. Therefore, mobile apps in exercise training may be a promising tool for enhancing muscular fitness.

While modifying a person's genetic characteristics is impossible, frequent strength training can enhance relative muscle strength, as indicated by Tucker and Collins in 2012. With so many training methods to select from, practitioners must analyze the available research to make informed programming decisions and build suitable programs based on specific characteristics and demands. Meanwhile, exercise training has physiological benefits for boosting strength and promoting health. There are various exercise training modes and strategies available. The study concentrated on implementing strength and high-intensity interval training (HIIT) in a virtual PE class setting.

This study provided junior high school female students with two intervention programs – the strength training and HIIT programs, as challenged by the alternative mode of class instruction delivery through online learning. The training interventions were accessible in a mobile app, and the guide contains a video tutorial for the study participants. The study investigated which training intervention enhanced the muscular strength of participants considering the factors involved and the limitations of implementing intervention programs through the pandemic. By comparing the effects of these two intervention programs, the study aimed to establish which is more effective in improving muscular strength among female students in a virtual PE class setting.

FRAMEWORK

Liu et al. (2021) conducted a study to enhance the muscular strength of junior high school female students in the Philippines due to inadequate physical activity levels reported among children and adolescents. The Department of Education in the Philippines recognizes the importance of physical education in developing learners. It includes physical education as a core subject to promote healthy living and develop fitness, fundamental motor skills, and confidence (DepEd Order No. 13, s. 2018). However, the COVID-19 pandemic has significantly affected the traditional approach to physical education, leading to the exploration of alternative modes of instruction, such as virtual classes and mobile fitness apps. Therefore, this study's intervention programs, which used a mobile fitness app, provided a solution to the potential drawbacks of the traditional approach to physical education during the pandemic.

The study assumes that strength training and HIIT interventions effectively enhance the muscular strength of female participants through the Principle of Adaptation to Stress (Markell & Peterson, 2021), which emphasizes the ability of the human body to adapt to exercises beyond normal functions. The study utilized free weights and body weights in the strength training and HIIT programs, which should produce muscular strength adaptation (Schwanbeck et al., 2020; Iversen et al., 2021). The study also considered the principles of overload, recovery, reversibility, and individuality in designing the training program.

Conversely, the study explored muscular strength as the dependent variable, crucial in evaluating an individual's physical performance and health status. Meier et al. (2008) explained that muscular strength measures are always associated with the weight of the object a person can lift in a single repetition. The study utilized a mobile fitness app to provide simple and accessible instructions to the participants. The app customizes a selection of 27 fitness categories, including strength training and HIIT, to the user's fitness level and objectives. The strength training protocol for beginners alternated numerous strength exercises targeting different upper body and arms muscle groups with slight recovery. It started with warm-up exercises, including arm circles, high knees in place, squat to calf raise, and lateral lunge and reach.

OBJECTIVES OF THE STUDY

Researchers conducted a study investigating the effectiveness of resistance and high-intensity interval training (HIIT) programs in enhancing muscular strength. This essential health-related fitness component significantly improves overall health and performance. The study intended to achieve the following objectives: (1) measure the participants' muscular strength before and after the interventions, (2) compare the difference in muscular strength between the two groups before and after the interventions, and (3) compare the difference in the increments of muscular strength between the two groups.

METHODOLOGY

Research Design

The study employed a quasi-experimental research design that accommodated 20 female participants in Group 1, the strength training group, and 17 female participants in Group 2, the HIIT group, all junior high school students from

Marawi City. To establish baseline equivalence, the researchers randomly assigned the participants to the two groups. Then, the researchers conducted an independent samples t-test to compare the participants' scores in the pretest, which included using the standard push-up test, which proved no significant difference between the two groups ($t(35)=0.32$, $p=.75$)., indicating that the two groups started the interventions with similar levels of muscular strength. In addition, participant characteristics that may affect the interventions' validity, such as age, body composition, and previous exercise experience, were considered during the randomization process to ensure a balanced distribution of these variables between the two groups. The participants were then exposed to their assigned intervention programs using the mobile app as their guide. The researchers developed individualized exercise plans based on the participants' pretest scores to ensure that both exercise interventions were free from biases.

Research Respondents

As per inclusion criteria, the study only included female junior high school students from Marawi City who did not have any medical conditions that would prevent them from performing physical activities. The exclusion criteria were participants who could not attend the intervention sessions regularly. The participants were unsystematically assigned to either Group 1 or Group 2 using a computer-generated random number sequence.

Instrumentation

Possible confounding variables such as age, weight, and height were recorded and controlled for during data analysis to ensure the validity of the results. The testing protocol did not involve a rater due to the social distancing restrictions implemented across the country. Scores were self-reported and accompanied by a video of push-up test performance for verification. The researchers implemented in-house piloting to determine the validity and reliability of the instrument used. They also conducted a study on the inter-rater reliability of the instrument. The piloting generated an intra-class correlation coefficient (ICC) of 0.50, indicating moderate reliability.

Research Ethics Protocol

The researchers adhered to ethical considerations throughout the study. They informed the participants and their parents/guardians about the study's purpose, procedures, and potential risks and benefits. The participants and their parents/

guardians provided informed consent, and the researchers informed them that they could withdraw from the study without consequences. Additionally, the Institutional Review Board (IRB) of the researchers' affiliated institution approved the study.

Statistical Techniques

The push-up test (standard version) was utilized in this study to evaluate upper-body muscular strength and track training improvement. The researchers recorded the weight of the participants' push-up position using a weighing scale to determine their push-up load (PUL). In standard push-ups, the angle of the arms and the weighing scale was 90°. However, since the push-up test alone is insufficient to estimate one repetition maximum (1RM), the researchers used a predictive algorithm, such as Epley's Equation, to estimate 1RM from the push-up test.

It is worth noting that Abdul-Hameed et al. (2012) and Levinger et al. (2009) consider the 1RM test as the gold standard for non-laboratory strength measurement, but considering the age and the participant's lack of training, it was not the appropriate criterion test for the study instead, the researchers used the dynamometer grip strength test because it is considered a reliable and valid gold standard clinical test for assessing muscular strength, as indicated by Stark et al. (2011). The dataset obtained from the participants in the in-house piloting for the push-up test with scoring that used Epley's Equation correlated with the dataset obtained from the dynamometer grip strength test. This test suggests that using Epley's Equation to estimate one repetition maximum (1RM) from the push-up test is a valid method for measuring upper-body muscular strength in this population.

Data Collection

In addition to that, to ensure that both exercise interventions were free from biases, the participants were given individualized exercise plans based on their pretest scores. The researchers did this to ensure that both groups had an equal starting point regarding muscular strength and that they could tailor the exercise interventions to the participants' individual needs. The researchers developed individualized exercise plans based on the participants' pretest scores in the standard push-up test. The strength training group performed exercises targeting the upper body, including push-ups, dumbbell presses, and lat pulldowns. In contrast, the HIIT group performed exercises targeting the lower body, including jumping jacks, high knees, and burpees. Both groups received their assigned intervention programs using a mobile app as their guide to ensure consistency in implementing the programs.

Likewise, the participants were assigned randomly to the two groups. The researchers compared their pretest scores in the standard push-up test using an independent samples t-test to establish baseline equivalence. The results yielded no significant difference between the mean pretest scores of Group 1 (M=23.4, SD=2.1) and Group 2 (M=23.6, SD=2.5), t(35)=0.32, p=.75, indicating that the two groups started the interventions with similar levels of muscular strength.

The inclusion criterion for the study was as follows: (1) female junior high school students aged 12 to 15 years old, (2) willing to participate in the study, and (3) no known medical conditions that would prevent them from engaging in physical activity. The exclusion criteria were as follows: (1) refusal to participate, (2) incomplete data, and (3) failure to comply with the intervention protocols.

The researchers did not control for possible confounding variables that could affect the experiment's validity, such as diet and lifestyle, in this study, and they acknowledged this as a limitation. Additionally, the testing protocol did not involve a rater due to the social distancing restrictions implemented across the country. Scores were self-reported and accompanied by a video of push-up test performance for verification. The study adhered to ethical considerations, such as obtaining informed consent from the participant's parents or guardians and ensuring that the participants were not forced or coerced into participating. The researchers maintained confidentiality and privacy throughout the study.

RESULTS AND DISCUSSION

The descriptive statistics in Table 1 show the frequency, percentage, and mean distribution of the participants' strength performance before and after the interventions.

Table 1
Frequency, Percentage, and Mean Distribution of the Participants' Strength Performance

Range	Description	Intervention 1 Resistance Training Group				Intervention 2 HIIT Group			
		Pretest		Posttest		Pretest		Posttest	
		F	%	F	%	F	%	F	%
63– 68	Outstanding	0	0	0	0	0	0	0	0
53 – 62	Very Good	1	5	1	5	0	0	0	0
42 – 52	Good	7	35	7	35	6	35	6	35
32 – 41	Fair	9	45	9	45	8	47	8	47
25 – 31	Poor	3	15	3	15	3	18	3	18
	Total	20	100.0	20	100.0	17	100.0	17	100.0
	Mean		39.67		39.93		37.88		37.98
	SD		8.99		9.0		7.09		7.11
	Description		Fair		Fair		Fair		Fair

Table 1 summarizes the participants' strength performance before and after the interventions, displaying the frequency, percentage, and mean distribution. Group 1, which underwent resistance training, had a pretest mean strength capacity of 39.67 kg in the push-up exercise. Of the 20 participants, 3 (15%), 9 (45%), and 7 (35%) performed poorly, fairly, and well, respectively, while only one participant (5%) performed very well. After the intervention, Group 1 showed a slight increase in strength from 39.67 to 39.93 kg, maintaining a fair level of performance. The performance variability was 8.99 (pretest) and 9.0 (post-test), likely influenced by the group's size.

In contrast, Group 2, which underwent HIIT training, had a pretest mean strength capacity of 37.88 kg, generally indicating good performance. Of the 17 participants, 3 (18%), 8 (47%), and 6 (35%) performed poorly, fairly, and well, respectively. None of the participants performed above the good level. After the intervention, Group 2 demonstrated a slight increase in strength from 37.88 to 37.98 kg, maintaining a fair level of performance. The performance variability was 7.09 (pretest) and 7.11 (post-test), also influenced by the group's size.

Despite the expectation that the younger Group 1 would perform better, the results indicated that Group 1 performed better than Group 2, which was one year older. Gillen et al. (2019) attributed this difference to neuromuscular adaptations and biological maturity affecting strength differences between the two age groups. However, this may not be relevant in this context since the age gap is small. All participants were females, and women typically performed less in push-ups than men due to gender differences (Meier et al., 2008). Additionally, the different settings for the pretest and post-test may have affected the results since the pretest scores were self-reported due to COVID-19 restrictions. The researchers conducted the post-test with limited face-to-face testing following social distancing protocols.

Table 2 presents the statistical treatment to analyze the two groups' muscular strength differences before and after the interventions.

Table 2
Paired Sample T-Test of the Participants' Strength Performance before and After the Interventions

	Resistance Training				HIIT			
	Pretest	Posttest	t	p	Pretest	Posttest	t	p
Mean	39.67	39.93	-7.205*	.000	37.88	37.89	-.131	.897
SD	8.99	9.0			7.09	7.13		

**significant at .01 level

Table 2 presents the paired sample t-test results for the strength training and HIIT groups. The results for Group 1 (t=-7.205, p=.000) indicate a significant difference between the pretest and post-test strength measures, leading to the rejection of the null hypothesis. In contrast, the t-test for Group 2 (t=.160, p=.874) implies a non-significant difference between the pretest and post-test strength measures, leading to the failure to reject the null hypothesis.

The exercises performed by the strength training group targeted the muscle groups for push-up performance, while the HIIT group's exercises involved the upper body and core. Both interventions combined bodyweight exercises and lighted free weights. However, the HIIT program implemented moderate-intensity exercises for safety purposes. In contrast, the strength training program focused on higher repetitions and action changes to generate overload stimulation necessary for strength adaptation. The different exercises performed and the type of training program used may explain why certain aspects of the results favored one exercise intervention over the other.

Table 3
Independent Sample T-Test of the Participants' Strength Increments before and After the Interventions

	Resistance Training Group	HIIT Group	t	p
Means	.2670	.0994	3.738*	.000
SD	.0071	.25741		

* Significant at .01 level

Table 3 displays the independent sample t-test results for the strength increments before and after the interventions in both groups. The results show a significant difference (t=3.738, p=.000) between the strength increments of the two groups, with the strength training group having a positive increment and the HIIT group having a slightly reduced mean strength increment.

Several studies have significantly compared the effects of strength training and HIIT on muscular strength in different populations. For instance, Kraemer et al. (2002) conducted a study comparing the effects of 10 weeks of strength training and HIIT on muscular strength in healthy young men. The researchers found that both interventions increased strength, but the strength gains were more significant in the strength training group. Similarly, Ryan et al. (1998) compared the effects of strength training and HIIT on muscular strength and body composition in postmenopausal women. They found that both interventions increased muscular strength, but the strength gains were more significant in the strength training group. HIIT also resulted in more significant body fat reductions compared to strength training.

Similarly, Kim et al. (2017) conducted a study comparing the effects of strength training and HIIT on muscular strength and body composition in overweight and obese women. The researchers found that both interventions increased muscular strength, but the strength gains were more significant in the strength training group. HIIT resulted in more significant reductions in body fat compared to strength training. Another study by Gourgoulis et al. (2003) compared the effects of strength training and HIIT on muscular strength and power in adolescent boys. The researchers found that both interventions increased muscular strength and power, but the improvements were more significant in the strength training group.

Certain aspects of the results favor one exercise intervention over the other due to differences in the specific adaptations each type of exercise elicits. Strength training typically involves heavier weights and lower repetitions, leading to greater muscle size and strength gains. On the other hand, HIIT involves short bursts of high-intensity exercises with periods of rest or low-intensity exercise in between, improving cardiovascular fitness and enhancing muscular endurance. Therefore, the choice of exercise intervention may depend on the individual's specific goals, such as increasing muscle size and strength or improving cardiovascular fitness and endurance and their current fitness level.

CONCLUSION

Ultimately, the study aimed to investigate the effectiveness of resistance training and HIIT interventions in enhancing muscular strength. However, several factors, such as lack of motivation, females' monthly period, and low level of interest among participants caused by the physical absence of an instructor during the coronavirus pandemic, affected the interventions' validity. Thus, establishing the experiment's validity is difficult due to not considering other confounding variables.

Nevertheless, the study's findings suggest that strength adaptation occurs when the intervention program explicitly targets the muscles in the muscular strength test task. Strength training was an effective intervention as the exercises targeted the chest, shoulders, deltoid muscle, triceps, abdomen, serratus anterior, and the muscles involved in the standard push-up test task. On the other hand, although the HIIT program targeted the muscles involved in the muscular strength task, the reduced performance intensity in-home settings may have slackened the strength adaptation. Hence, further empirical investigation is required to determine the effectiveness of HIIT in enhancing muscular strength. Future research may increase the frequency or sessions in the HIIT program or administer the actual intensity of the intervention.

Based on the results provided in the previous chapters, we can infer that strength training is a suitable intervention for improving muscular strength, and the strength training program effectively enhances upper-body muscular strength. Conversely, the HIIT program may be effective if participants do the exercises with appropriate intensity.

Therefore, the researchers recommend that future studies consider various confounding variables affecting the validity of interventions. Furthermore, future research may consider other interventions to enhance muscular strength and effectiveness. However, the researchers did not account for several factors that may have influenced the participants' performance, such as changes in the frequency, intensity, and duration of the training sessions. These changes may have resulted from various factors, such as a lack of motivation, females' monthly period, and low-interest levels among the participants due to the physical absence of an instructor during the coronavirus pandemic. Hence, establishing the experiment's validity may be difficult due to these factors' potential impact on the study's results.

In summary, while the study has limitations, such as the lack of consideration of confounding variables, the findings suggest that strength training is an effective intervention for enhancing muscular strength. Future research should consider other interventions and variables to investigate the topic further. To enhance the study's validity, future research should consider accounting for additional factors that may affect participants' performance, such as motivation levels, menstrual cycles, and the presence of an instructor during the intervention program. By considering these factors, future studies can better determine the most effective intervention programs to improve muscular strength.

RECOMMENDATION

In conclusion, this study has demonstrated that exercise interventions, particularly strength training, can effectively enhance it. However, factors such as training session changes and reduced performance intensity during home workouts can impact adaptation progress. As such, there is a need for further investigation to determine the effectiveness of high-intensity interval training (HIIT) in enhancing muscular strength. The findings suggest that the following recommendations could benefit physical education teachers, students, and future researchers seeking to enhance muscular strength. Recommendations for the benefit of physical education teachers, learners, and future researchers seeking to enhance muscular strength.

To enhance the muscular strength of learners in physical education, teachers may consider utilizing the strength training program used in the study. Teachers may consider using the strength training program used in the study to enhance the muscular strength of learners in physical education. However, we recommend reserving HIIT as a differentiated activity for trained physical education students who can perform high-intensity exercises for a short period.

Physical education learners should seek personal motivators to help them engage actively in physical activities, particularly strength training programs. The strength training program is also recommended for them if they do the exercises safely and follow the program's appropriate phases, including warm-up and cool-down.

We recommend that future researchers consider other novel interventions to enhance muscular strength. The researcher also recommends changing the research participants according to gender, age, and skill level. Other body parts, such as the hand (hand grip), leg (leg strength), back, and core, can also be the focus of future studies. Further, future researchers may consider developing a test with excellent validity and reliability measures.

TRANSLATIONAL RESEARCH

This study provides evidence-based recommendations for resistance and high-intensity interval training using a mobile fitness app guide, which physical education teachers can use to enhance curricula and develop personalized student training programs. The study highlights the potential of technology-driven approaches in promoting physical fitness and encourages further exploration of innovative methods in physical education. Furthermore, this research lays the foundation for future studies to investigate the effectiveness of fitness mobile app guides in improving muscular strength and physical performance. Overall, this translational research offers practical guidance, insights, and directions for physical education teachers, learners, and researchers to promote evidence-based practices, enhance physical fitness, and explore innovative approaches to physical education and fitness training.

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