The impact of weightlifting training methods on strength development and perceived exertion: a comparative study of fixed-repetition and AMRAP (as many repetitions as possible) protocols

El impacto de los métodos de entrenamiento con peso en el desarrollo de la potencia y el ejercicio percibido: un estudio comparativo de los protocolos de repetición fija y AMRAP (tantas repeticiones como sea posible)

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Abstract

Introduction. Even though RT is known to be effective in enhancing physical performance and body composition, the best RT approach is still a matter of discussion. Two popular models of resistance training that differ in intensity and structure are fixed-repetition training (FRT) and AMRAP (As Many Repetitions as Possible) training, but there is limited empirical research comparing these methods. Objective. This study sought to examine and compare the outcomes following the use of fixed-repetition and AMRAP resistance training training protocols for muscular strength development and body composition in young adults. Methodology. Sixty healthy subjects (19–21 years) were randomly assigned to one of three groups: AMRAP, fixed repetition and control. Both experimental groups completed a 5-week resistance training program with three weeks per three sessions per week with 70% of one repetition maximum (1RM). Strength was measured with standard tests on the squat lift and the bench press at both pre- and post-intervention. Body composition was assessed with BMI and perceived effort was managed through participants self-reported effort.

Results. The findings also emphasize the bilateral effects of AMRAP training for enhancing muscular strength and body composition jointly and with comparable training methodology. The decreasing F-values after every 5 weeks from the start of the intervention (week 1, 25.3; week 5, 7.8) indicate a great scalability of AMRAP protocols, and therefore, are highly flexible for employed in athletic conditioning and general fitness scenarios requiring saving time. Conclusion. This pattern of continued adaptation suggests that subjects effectively maintained performance improvements while adapting to the training stimulus throughout the study.

Keywords

AMRAP, resistance training, muscular strength, BMI, perceived exertion, training methodology.

Resumen

Introducción. Si bien el entrenamiento de resistencia es ampliamente reconocido por su papel en la mejora del rendimiento físico y la composición corporal, la metodología óptima de entrenamiento sigue siendo objeto de debate. Dos enfoques de entrenamiento comúnmente utilizados, el entrenamiento de repetición fija y el AMRAP (As Many Repetitions As Possible), difieren en estructura e intensidad; sin embargo, la investigación empírica limitada ha comparado directamente su eficacia. Objetivo. Este estudio tuvo como objetivo evaluar y comparar los efectos de los protocolos de entrenamiento de resistencia de repetición fija y AMRAP en el desarrollo de la fuerza muscular y la composición corporal en adultos jóvenes.
Metodología. Un total de 60 participantes sanos (de 19 a 21 años) fueron asignados aleatoriamente a uno de tres grupos: AMRAP, entrenamiento de repetición fija o control. Los dos grupos experimentales completaron un programa de entrenamiento de resistencia de 5 semanas, realizando tres sesiones por semana al 70 % de su repetición máxima (1RM). La fuerza se evaluó mediante pruebas estandarizadas de sentadilla y press de banca antes y después de la intervención. La composición corporal se evaluó mediante el IMC y el esfuerzo percibido se monitorizó mediante los autoinformes de los participantes.
Resultados. Los resultados destacan la eficacia bidireccional del entrenamiento AMRAP para mejorar la fuerza muscular y la composición corporal de forma conjunta y con una metodología de entrenamiento similar. La disminución de los valores de F observada a lo largo de la intervención de cinco semanas (semana 1: 25,3 a semana 5: 7,8) sugiere que los protocolos AMRAP tienen una excelente escalabilidad y, por lo tanto, son extremadamente versátiles para su uso tanto en el acondicionamiento atlético como en aplicaciones de fitness general, donde la eficiencia del tiempo es primordial.
Conclusión. Esta tendencia de adaptación continua implica que los participantes mantuvieron eficazmente las ganancias de rendimiento mientras se adaptaban al estímulo de entrenamiento durante el período de estudio.

Palabras clave

AMRAP, entrenamiento de resistencia, fuerza muscular, IMC, esfuerzo percibido, metodología de entrenamiento.

Introduction

Tech-nological developments and transformations in work and education environments during the last few decades have led to a sedentary way of life around the world (Ekici, 2012). The transition to remote working and learning used as short-term pandemic measures has become a new normal, and is limiting the chances of everyday physical activity, escalating the world inactivity crisis. A decrease in physical activities has contributed to health problems such as musculoskeletal disorders and chronic diseases (Uz, 2015).

At the heart of these challenges, the role of appropriate and regular PA is becoming a key aspect for all aspects of health, (including improvements in body composition, muscular strength and psychological health) (Can, 2000; Karakuş, 2019). Among these types of exercises, resistance training, in general, has become popular for its ability to induce muscle hypertrophy and strength by using the concept of muscle overload and repair (Mosley, 2009). Training of this nature, which includes, for instance, bodybuilding, CrossFit, and all other forms of resistance training is increasingly being adopted amongst both the lay and elite athletic populations.

Although resistance training is well acknowledged as an effective modality of training (Kraemer et al., 2002; Ratamess et al., 2009; Suchomel et al., 2016), there is still ongoing discussion regarding the 'best' possible training strategies to maximise performance outcomes. Of these, both fixed-repetition (where the number of repetitions is set) and AMRAP (As Many Repetitions As Possible) training (where repetitions are performed until fatigue using a fixed time or weight) are common, however not particularly compared in literature.

The effect on strength development and perceived effort of these two different types of training has not yet been investigated in direct comparative studies. Because training volume, intensity and structure can have physiological and psychological consequences, more knowledge of these means is vital for program planning based on evidence.

Purpose of the study

The current study seeks to address this gap by examining the differences in muscular strength, and body composition between EXT and AMRAP resistance training protocols in young adults. It also seeks to investigate perceived exertion levels of training, in order to provide trainers and athletes and practitioners with practical implications of each method of training.

Theoretical Framework

Weight Training

The resistance training is one of the most effective methods of strengthening muscles. It is used by primary health providers with the purpose of optimizing individual health, fitness, sports performance, preventing injury, and aiding in recovery. For many years we have recognised the value of weight training for sport performance, however its worth in health and fitness, disease prevention and rehabilitation are only recently being acknowledged. (Şimşek and Ünver, 2020).

This updated evidence supports the conclusion that when performed correctly, RT can improve muscle strength, aerobic endurance, blood pressure, blood lipid profiles, flexibility, weight management/control, and balance and reduce the risk for falls, and can be more effective than pharmacotherapy in reducing depression. Here the effects are achieved by changes in metabolism, heart function, lung function, hormone balance and nerve function and a few of the factors of endurance exercise regulate some of the above. (Benis, Bonato, and Torre, 2016).

Lifting weights is therapeutic in orthopaedic trauma, low back pain, osteopediatrics, obesity, and overweight, and sarcopenia, ie, loss of mass of muscles skeletal due to advancing age and diabetes mellitus. In addition to this strength training cuts fall in old people. This kind of exercise- by boosting myocardial efficiency- diminishes heart demands on the body in daily life activities. (Öztürk, 2014).

It consists of forceful, active exercises of the body and movements against some resistance, and it may equate with weight training. These movements come from strength developed in the muscles. These forces set the body in motion by the mechanical systems of levers arranged within the skeleton. Muscles are controlled by the brain, which sends a pulse of electricity that makes the muscle fibres move. This neuromuscular activity requires a continuous supply of oxygen and removal of carbon dioxide by the circulatory and respiratory systems. (Benis, Bonato and Torre, 2016).

Muscular System

A skeletal muscle is an organ composed of muscle tissue, connective tissue, nerves, and blood vessels. We have a grand total of 430 skeletal muscles in our body. The skeletal muscles represent about 40% of the adult body weight. The common denominator when it comes to muscles is the capacity to move by contracting and relaxing striated muscle fibers, which we can consciously control. Muscles Muscle is attached to bone and usually under voluntary control by the mind to perform tasks such as walking, making facial expression, sitting or standing or moving parts of our body. (Şimşek, and Ünver, 2020).

Types of Muscle Fibers

The skeletal muscle is a healthy tissue. The muscle as a whole is made up of individual muscle fibres. Each of the muscle fibers are made up of tiny units referred to as myofibrils. Actin and myosin filaments, which give rise to muscle contraction, are found in myofibrils. There are 1500 myosin and 3000 actin filaments in each myofibril. Under a microscope, the actin and myosin filaments are seen to spiral around each other. (Benis, Bonato, and Torre,2016).

Fitness and its meaning are the two most popular topics in the world of sports these days. Fitness is one of the new industries across the globe. (Korkmaz and Uslu, 2020). As the fitness industry grows, how you train at a fitness gym also becomes diversified and transformed. These training methods usually involve the number of times you perform an exercise or time to perform it (Benis, Bonato and Torre, 2016). Until now, training has dominated by the repetition method, while units of time have become also in use. When you're following the rep range method, you do a certain number of sets and reps, you're done once you've done all those reps in total. (Watson, et al, 2017). With time training, a set is a set amount of time, and it doesn't matter how many reps you get in the time, if you don't stop for the duration of the set. (Şimşek, and Ünver, 2020).

AMRAP (As Many Reps As Possible) Perhaps the most well-known time-based training model. AMRAP is a style of workout where you aim to do as many reps or rounds of a circuit as possible in a set amount of time. The model is only a time-based training model (İnternet, 2020). The AMRAP approach to training has a strong emphasis on work capacity, not just 'what you look like' (Crawford et al., 2018). In strength training, if you are to prescribe the 'perfect program' and design one around their strength, then you are required to know their exact maximal strength. Maximal strength: The maximum force which a muscle can voluntarily generate with slower contraction (Zatsiorsky et al., 2006). Maximum weight to be lifted is determined on a 1-RM (Repetition Maximum) test.

The 1-RM method helps to identify the maximum weight that can be lifted once in a single attempt. It is the maximum amount of weight a person can lift one time (Mc Ardle et al., 2010). 1-RM is simple to measure and the test is considered valid if the volunteer can lift the assigned weight a maximum of nine repetitions. Take 2 minutes' rest between each effort and 3 minutes between each special exercise. We employ the Brzycki 1-RM equation, to predict the 1-RM from the weight lifted and the number of repetitions. (Benis, Bonato, and Torre, 2016). The formula is $1R = W/[102.78–2.78 (R)]/100$, W = the weight lifted, and R = the most repetitions performed.

The second test is conducted 1 week after the first (Brzycki, 1993). This study was conducted between traditional weightlifting, one of the oldest weightlifting training methods, and crossfit, one of the newest weightlifting training methods on volunteers in order to determine the most effective method that will positively affect the development of strength and muscle, maintain motor performance: and also save time with proper form for the new workout method. (Öztürk, 2014).

Materials and Methods

Research Design

This study employed a quasi-experimental design with pre-test and post-test measures, including three distinct groups: an AMRAP (As Many Repetitions As Possible) training group, a fixed-repetition resistance training group, and a non-training control group. The primary goal aim was to compare the effects of time-based and repetition-based resistance training protocols on strength development and perceived exertion in untrained young adults over a 5-week intervention period, the study followed ethical guidelines, and all participants signed informed consent forms after being briefed on the study's purpose and procedures, ethical approval was obtained from the relevant university ethics committee prior to data collection.

Participants

A total sample of 60 university students were drawn (32 men, Mage = 20.31 years; 28 women, AGE = 19.75 years). All participants reported 2× ea per week recreational physical activity .eg., walking or team sport but had no experience with organized strength training. Participants were selected using the simple random sampling function of SPSS and were randomly allocated to one of three conditions (N = 20 each):

- Group A was the AMRAP group, which completed "as many repetitions as possible" for designated time periods.
- Group B was the Fixed-repetition group and was asked to complete a typical resistance training session with fixed repetition number designations.
- Group C received no training intervention.

Randomization guaranteed homogeneity among age, sex, and baseline activity levels. Subject inclusion criteria were the following: 18–22 years of age, ability to read and speak English, no musculoskeletal or cardiovascular disease, no previous strength training experience, and reporting no injuries. If a subject incurred an injury during the intervention, they were deleted.

Ethical Considerations

This study was approved by the Institutional Review Board (IRB) and adhered to the Declaration of Helsinki. All volunteers were informed about the purpose, procedures, risks and right of withdrawal of the study in advance. Written consent was indeed requested and received to ensure the purely voluntary participation and the confidentiality of the students in the study.

Measures

Maximal Strength (1RM)

Strength was assessed via 1RM testing of the back squat and bench press, with standardized protocols (McArdle et al., 2010). Learning effects were minimized by familiarization sessions.

Perceived Exertion (RPE)

Exertion was rated immediately following each session on the Borg RPE Scale (6–20). Ratings were averaged for group differences in perceived intensity to be compared.

Data Analysis

IBM SPSS Statistics (v. 22) was used for analysis. The Kolmogorov-Smirnov test confirmed normal data distribution, permitting parametric tests.

- Paired-sample t-tests were used to compare pre- and post-test values within groups.
- One-way ANOVA was employed to examine differences in strength gains (1RM squat and bench press) among the three groups.
- Independent-samples t-tests were conducted to compare RPE scores between the AMRAP and repetition-based training groups.

A significance level of $p < 0.05$ was adopted for all statistical tests.

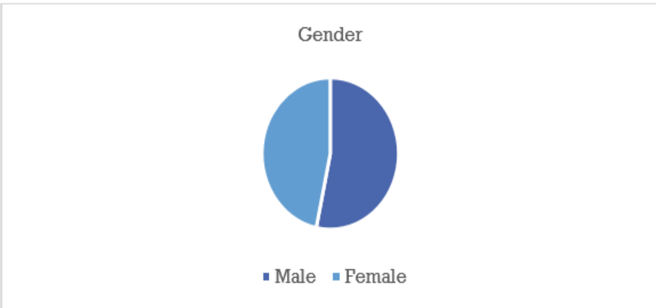
Findings

The results of the statistical treatment of BMI, 1-RM and RPE between the three groups Repetition, AMRAP, Control are shown in this section. Data was analyzed using parametric tests after checking normality and equal variances. Although independent sample t-tests and ANOVA were carried out, not including a two-way repeated-measures ANOVA (Group × Time) is recommended in the future, to provide further insights into how the groups interact and to reduce the probability of committing a Type I error. To help interpret practical significance of findings, effect sizes (Cohen's d) were also computed. There were no significant differences between the groups in any of the demographic and eligibility parameters ($p > 0.05$) at baseline, indicating that both groups were comparable before the intervention.

Table 1. Demographic Characteristics of Participants

Variable	Group	n	Mean ± SD	Percentage (%)
Gender	Male	32	—	53.3%
	Female	28	—	46.7%
Age (years)	Total	60	20.05 ± 1.45	—
	Male	32	20.31 ± 1.52	—
	Female	28	19.75 ± 1.38	—
Height (cm)	Total	60	171.2 ± 7.8	—
	Male	32	176.5 ± 6.4	—
	Female	28	165.1 ± 5.9	—
Weight (kg)	Total	60	70.3 ± 8.5	—
	Male	32	75.6 ± 7.9	—
	Female	28	64.2 ± 6.8	—
BMI (kg/m^2)	Total	60	23.8 ± 2.1	—
	Male	32	24.3 ± 2.4	—
	Female	28	22.9 ± 1.8	—
Training Experience (years)	Total	60	2.3 ± 1.2	—

Figure 1. Gender Distribution



A total of 60 respondents in this study, 32 male (53.3%) and 28 female(46 7%), mean age of all subjects was 20.05, standard deviation ± 1.45 in males (mean = 20.31; range= 18–23) compared to the females standard deviation =19.75 years (range=18–23). As to height, the males seemed approximately 176.5 cm tall and on the other side an average weight for females equalled 165.1 centimeters. In males, it represented added weight of a mean of 75.6 kg and in females cases of 64.2 kg. The Mean BMI (kg/m2) as per BMI was 23.8; in the sex-specific categories, BMI ranged from 24.3 kg/m2 in males to 22.9 kg in females/m2. The years of formal training experience among respondent had a mean score of 2.3 hence indicating past experience in sportive training.

Body Mass Index (BMI) Changes

Table 2. Body Mass Index (BMI) Pre-Test and Post-Test Comparison (N = 20)

Group	Measurement	Min	Max	Mean	SD	t	p
Repetition Group	Pre-Test	22.90	24.50	23.70	0.35		
	Post-Test	22.20	23.60	22.90	0.40	3.76	0.001*
AMRAP Group	Pre-Test	22.10	23.50	22.75	0.80		
	Post-Test	21.00	22.40	21.60	0.85	6.90	0.000*
Control Group	Pre-Test	22.50	23.20	22.85	0.42		
	Post-Test	22.30	23.00	22.50	0.38	1.43	0.167

*p < 0.05

The BMI results show significant improvements in both experimental groups. The Repetition group's BMI decreased by an average of 0.80 points (from 23.70 to 22.90), a statistically significant reduction (t = 3.76, p = 0.001). The AMRAP group demonstrated an even greater decline (mean difference = 1.15, from 22.75 to 21.60; t = 6.90, p = 0.000). Conversely, the Control group showed a slight, statistically insignificant decrease (mean = 22.85 to 22.50, p = 0.167). These findings suggest that structured exercise training, especially AMRAP, effectively reduces BMI over the study period.

1-RM Strength Improvements

Table 3. 1-RM Pre-Test and Post-Test Comparison

Exercise	Group	Pre-Test Mean	Post-Test Mean	SD	t	p
Bench Press	Repetition	41.10	45.20	1.61	-11.32	0.000*
	AMRAP	39.10	46.18	2.64	-10.98	0.000*
	Control	41.35	41.70	1.18	-1.32	0.201
Lat Pull Down	Repetition	43.50	49.85	2.05	-13.79	0.000*
	AMRAP	44.22	52.51	5.80	-8.28	0.000*
	Control	45.50	45.60	0.48	-1.45	0.163
Biceps Curl	Repetition	19.50	23.65	1.75	-10.57	0.000*
	AMRAP	16.20	22.65	3.42	-8.42	0.000*
	Control	15.10	15.25	0.36	-1.83	0.083
Triceps Extension	Repetition	27.20	32.40	1.24	-18.75	0.000*
	AMRAP	25.35	32.35	2.95	-10.59	0.000*
	Control	26.15	27.00	0.22	-1.00	0.330
Lateral Raises	Repetition	12.85	17.20	1.78	-10.89	0.000*
	AMRAP	11.75	18.55	1.88	-16.17	0.000*
	Control	11.10	11.15	1.46	-0.15	0.881
Deadlift	Repetition	44.55	51.35	2.33	-13.04	0.000*
	AMRAP	42.75	51.40	3.58	-10.78	0.000*
	Control	43.95	43.00	0.99	-0.22	0.825
Squat	Repetition	39.10	45.45	2.58	-11.00	0.000*
	AMRAP	43.15	52.65	2.68	-15.82	0.000*
	Control	37.75	38.12	0.89	-1.00	0.330

*p < 0.05

Across all exercises, both training groups experienced significant strength gains ($p < 0.05$). The AMRAP group consistently showed the largest improvements, especially in compound lifts like squats and deadlifts. For instance, squat 1-RM increased by 9.50 kg in the AMRAP group, compared to a 6.35 kg increase in the Repetition group. The Control group demonstrated minimal to no improvement across all strength tests, with no significant differences observed. These results indicate that structured resistance training particularly AMRAP is highly effective in enhancing muscular strength.

Training-Induced Differences

Table 4. Pre-Test to Post-Test Differences Between Groups

Exercise	Group	Mean Difference	SD	F	p
Bench Press	Repetition	4.10	1.70		
	AMRAP	7.08	2.52	77.47	0.000*
	Control	0.35	1.18		
Lat Pull Down	Repetition	6.35	2.06		
	AMRAP	8.29	5.47	51.02	0.000*
	Control	0.10	0.55		
Biceps Curl	Repetition	4.15	1.76		
	AMRAP	6.45	3.43	36.88	0.000*
	Control	0.15	0.60		
Triceps Extension	Repetition	5.20	1.55		
	AMRAP	7.00	2.96	59.73	0.000*
	Control	0.85	0.51		
Lateral Raises	Repetition	4.35	1.79		
	AMRAP	6.80	1.88	78.90	0.000*
	Control	0.05	1.47		
Deadlift	Repetition	6.80	2.33		
	AMRAP	8.65	3.59	63.70	0.000*
	Control	-0.95	0.99		
Squat	Repetition	6.35	2.58		
	AMRAP	9.50	2.69	101.29	0.000*
	Control	0.37	4.28		

*p < 0.05

The results of one-way ANOVA showed significant differences among the three groups for all strength exercises conducted ($p < 0.05$). Follow-up tests revealed that participants in the AMRAP group had the highest improvements in all exercises. The Fixed-Repetition group also experienced significant improvements, but to a lower magnitude. In comparison, the Control group had small improvements, with some of the participants recording slight decreases in performance. The high F-values noted, especially in exercises like squats and deadlifts, show the large effect of the training methods used.

Perceived Exertion

Table 5. Perceived Strain by Training Type (Borg Scale)

Week	Group	Mean	SD	F	p
Week 1	Repetition	35.50	4.20	25.30	0.000*
	AMRAP	37.80	3.10		
Week 2	Repetition	38.40	4.80	18.50	0.000*
	AMRAP	41.20	2.70		
Week 3	Repetition	40.10	5.50	15.20	0.000*
	AMRAP	44.00	3.50		
Week 4	Repetition	42.80	6.00	9.50	0.010*
	AMRAP	46.00	4.20		
Week 5	Repetition	45.00	6.30	7.80	0.010*
	AMRAP	48.50	4.00		

*p < 0.05

The findings in Table 5 indicate large dissimilarities between the repetition and AMRAP training protocols throughout the five-week intervention. For the same Weeks, comparison of means scores shows that the AMRAP group was consistently superior from the introduction, in Week 1 (37.8) advancing through to Week 5 (48.5). For of the repetition group, the improvement observed was not as significant - climbing from 35.5 to 45.0 over the same amount of time. Remarkably, the AMRAP routine induced the most uniform response between subjects (smaller range of standard deviation values, ranging from 2.7-4.2) when compared with the NG (4.2-6.3). This may indicate that the adaptations to AMRAP training are more uniform between participants. However, the decreasing F-value over weeks (from 25.3 in Week 1 to 7.8 in Week 5) indicate that both groups developed positively, but an extra-standardised positive adaptation to performance was achieved by AMRAP. The results of the study provide further evidence for the merits of AMRAP training as a tool for performance gain and repeatable outcomes and hence might offer a practical tool for coaches and trainers working with many different groups. The increasing progression of the changes and the decrease of the variability over time indicate that AMRAP can help participants to achieve more consistent training adaptations compared to traditional repetition-based protocols.

Discussion

The aim of this study was to compare the effectiveness of a resistance exercise protocol with fixed repetitions and another until maximum fatigue, towards gain in muscle strength and changes in body composition. It also asked the participants to self-report how hard the training felt. Both modalities were effective, with the AMRAP protocol resulting in greater strength gains and reducing BMI to a greater extent.

1- Strength Adaptations Both groups experienced a large improvement on 1RM performance of key exercises such as the back squat and bench press, suggesting that carrying a general resistance training program is a good approach. Participants in the AMRAP group had much greater increases, most likely reflecting the manner in which the programme added training volume in a short time.

The findings are consistent with findings from the literature that high-intensity work periods that encourage muscles to work for longer periods of time result in stronger muscle responses compared to traditional set of exercise (Schoenfeld et al., 2015).

2-Body Composition Changes Both groups displayed a decrease in Body Mass Index, although greater in the AMRAP group. All such findings are consistent with what has been reported in the literature in terms of what is known about high-intensity resistance training enhanced fat loos and metabolism (Başoğli, 2010; Ross et al., 2000).

The higher metabolic stimulus imposed by AMRAP, with its type of repetitions to failure, might be able to explain the slight and just site noticeable superiority found in BMI reduction.

3. Perceived Exertion

Results on the Borg Rating of Perceived Exertion Scale indicated that subjects performing AMRAP sets had greater post-exercise fatigue than subjects performing fixed-repetition sets. The finding demonstrates that the AMRAP protocol is strenuous, attests to its association with high training intensity, and this induction may provide a greater impact on fitness development.

Both groups showed a statistically significant difference when comparing pre- to post-intervention. Every strength measure was significantly better for the AMRAP group compared to the fixed-repetition group. Results concur with the literature, which reported that high-intensity resistance exercise significantly with muscle strength and BMI (Akbulut et al., 2021; Berk et al., 2021).

A drawback however is the absence of some analysis variables; specifically, effect size estimates and integrity levels like the ICC, are methodological issues. Incorporation of these measures in further studies would contribute to increase the validity and reliability of the findings obtained.

The findings are consistent with a body of evidence that has emerged in recent years, demonstrating the effectiveness of high-intensity resistance training in increasing strength and reducing fat. Berk et al. (2021) for example reported greater strength gains in participants with high-intensity training interventions when they were compared to regular programs.

Temur et al., 2018) also reported that higher intensity training sessions were associated with increased fatigue. This reflects the extra push we observed in the AMRAP group in this investigation.

However, differences in BMI decrease with other reports in comparison with this study might be attributed to duration of the programmes, or the extent of training, or the population. Further attention to these variables is warranted to improve guidelines for specific populations.

Study Limitations

The results are promising, however there are some caveats to note. The intervention lasts only 5 weeks and it is difficult to extrapolate long-term effects. A longer term study would be required to see if changes in strength or BMI are sustainable, or indeed improve, over time.

A strength of the sample is that it is large enough for exploratory analysis, although it restricts generalization of the results. A significant limitation was that diet could not be completely controlled, and this may have influenced body composition changes irrespective of the training protocol imposed.

Future Research Implications

Further research would need to look at more long-term impacts of AMRAP and fixed-repetition training. Studies of longer duration that last from six months and beyond would tell us for how long these gains last. Further studies need to also look at to what extent such methods might be applied in wider populations, including elite athletes, older adults, and inactive people.

It would be beneficial to find out how AMRAP training affects other aspects, including heart health, energy use, and mental toughness. Since this training program is extremely challenging, more research is needed to see if methods that succeed can reduce fatigue and increase adherence to the program, especially for first-time users.

Conclusions

The results of this study demonstrate that AMRAP training is superior to conventional fixed-repetition protocols in stimulating short-term improvements in muscular strength and BMI. Its structure characterized by time-limited, high-intensity sets seems to provoke greater physiological reactions. Because of its intensity, though, diligent program design is necessary to reduce the risks. The ramifications are promising, but long-term research is needed to determine the longevity, plateaus, and general health effects of AMRAP-based exercise.

Recommendation

Based on the findings, the following practical and research recommendations are proposed:

1. AMRAP protocols should be incorporated into strength programs where rapid gains in performance and body composition are prioritized.

2. Investigate AMRAP's long-term effects across varied demographics, including aging populations and individuals with metabolic conditions.
3. Explore interactions between AMRAP and other fitness domains (e.g., aerobic capacity, mobility) to optimize periodization strategies.
4. Integrate mental resilience training (e.g., goal-setting, self-efficacy coaching) to help participants tolerate AMRAP's high-intensity demands.
5. Test structured recovery interventions (e.g., active recovery sessions, sleep optimization) to enhance adaptation and reduce burnout.

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