

## The Acute Effect of Emom vs Amrap Protocol in Crossfit Training on Muscle Strength among Healthy Adults

Nadhirah Lisa Diyana Mohd Firdaus<sup>1</sup>, \*Maisarah Shari<sup>1</sup>, Raja Nurul Jannat Raja Hussain<sup>2</sup>, Noor Azila Azreen Md Radzi<sup>2</sup>, Wan Ahmad Munsif Wan Pa<sup>3</sup>, Mohamad Firdaus Ahmad<sup>2</sup>, Ellail Ain Mohd Aznan<sup>4</sup>, Ali Md Nadzalan<sup>5</sup> & Nurul Ain Abu Kasim<sup>2</sup>

<sup>1</sup>Department of Sports Science, Faculty of Sports Science and Recreation, Universiti Teknologi MARA, 40450 Shah Alam, Selangor, Malaysia, <sup>2</sup>Department of Sports Science, Faculty of Sports Science and Recreation, Universiti Teknologi MARA, 70300 Seremban, Negeri Sembilan, Malaysia, <sup>3</sup>Department of Education and Community Welfare Studies, Faculty of Educational, Universiti Kebangsaan Malaysia, 43600 Bangi, Selangor, Malaysia, <sup>4</sup>Department of Sports Management, Faculty of Sports Science and Recreation, Universiti Teknologi MARA, 02600 Arau, Perlis, Malaysia, <sup>5</sup>Department of Coaching Science, Faculty of Sports Science and Coaching, Universiti Pendidikan Sultan Idris, 35900 Tanjung Malim, Perak, Malaysia

\*Corresponding Authors Email: maisarahshari@uitm.edu.my

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### Abstract

CrossFit training is a high-intensity fitness training regimen that merges a variety of physical exercises, where it is designed to improve overall fitness and health, targeting multiple domains such as stamina, strength, flexibility, speed, coordination, and balance. Despite that, the existing literature on CrossFit training reveals a noticeable gap in studies specifically there are limited studies conducted comparing EMOM (Every Minute on Minute) and AMRAP (As Many Repetitions as Possible) protocols in CrossFit and lack of data examining the acute effect of CrossFit training. Thus, this study aimed to determine the acute effects of two CrossFit training protocols EMOM and AMRAP on the muscle strength of healthy adults. A quasi-experimental design was employed, with pre-test, ongoing test, and post-test assessments conducted on eight selected healthy adults. The eight participants, including 4 males and 4 females, underwent a pre-test, EMOM (2 days following the pre-test), ongoing test (2 days following the EMOM session), a washing period for 7 days, an AMRAP session, and a post-test. The upper and lower body strength test was evaluated using bench press and leg press exercises. There were no statistically significant differences found between the EMOM and AMRAP protocols in both upper and lower body strength, as  $p > .05$ . However,

AMRAP demonstrated a slightly greater magnitude of improvement in muscle strength by 28.04% in upper body strength and 10.59% in lower body strength. This suggests that AMRAP may be more effective for enhancing muscle strength, but further research with larger sample sizes is warranted to confirm these findings.

**Keywords:** CrossFit Training, Acute Effect, EMOM, AMRAP, Healthy Adults

### **Introduction**

The REDISCOVER (Responding to Increasing Cardiovascular Disease Prevalence) study in Malaysia, which included 13,654 participants, reported insufficient physical activity among adults, particularly those residing in rural areas and with lower socioeconomic status (Nik-Nasir et al., 2022). This inactivity is contributing to rising rates of obesity and non-communicable diseases such as cardiovascular, musculoskeletal, and respiratory disorders. To counter these trends, global guidelines recommend adults engage in 150–300 minutes of moderate-intensity or 75–150 minutes of vigorous-intensity exercise weekly (Yang, 2019). However, traditional training modalities often face adherence issues due to monotony, time constraints, or lack of visible short-term results.

In recent years, High-Intensity Functional Training (HIFT), particularly CrossFit, has gained popularity as an effective and time-efficient alternative. CrossFit blends strength training, aerobic conditioning, and functional movements in a high-intensity format. It is accessible across various age groups and fitness levels and has shown promise in improving cardiovascular fitness, muscular strength, and body composition (McWeeny et al., 2020; Chukhlantseva et al., 2020). However, despite its widespread use, empirical research on CrossFit's acute physiological effects remains limited—particularly with regard to comparing its specific protocols such as EMOM (Every Minute on the Minute) and AMRAP (As Many Rounds as Possible).

Both EMOM and AMRAP are commonly used within CrossFit sessions and are known to elicit different physiological responses. EMOM promotes structured effort and recovery within each minute, potentially enhancing pacing and technique, while AMRAP emphasizes continuous effort, which can increase metabolic stress and muscular fatigue (Tibana et al., 2018; Foster et al., 2017). While anecdotal and practitioner-based evidence supports both methods, few scientific studies have directly compared their short-term (acute) effects on muscle strength.

Understanding which protocol offers more immediate benefit to muscle strength is essential for multiple stakeholders. This includes fitness coaches, strength and conditioning professionals, health practitioners, and individuals seeking time-efficient and effective training strategies. Moreover, as CrossFit continues to expand globally—including in Malaysia—this study addresses a pressing need for evidence-based exercise prescriptions, especially for adults aiming to improve their physical fitness without committing to long-term interventions. Therefore, this study aims to evaluate and compare the acute effects of EMOM and AMRAP protocols on upper and lower body muscle strength in healthy adults. By identifying the more effective protocol in the short term, the findings could support better programming choices in both fitness and rehabilitation settings, contributing to improved health outcomes and exercise adherence.

## **Literature Review**

CrossFit training, particularly the EMOM and AMRAP protocols, is widely employed to enhance muscular strength. These two methods differ in structure: EMOM incorporates controlled work-rest cycles, whereas AMRAP emphasizes continuous effort within a fixed time frame. Research has shown that both protocols can improve muscular strength, endurance, and hypertrophy; however, there is limited direct comparison of their acute effects on muscle strength (Tibana et al., 2018). While CrossFit's varied exercises are known to stimulate neuromuscular adaptations, it remains unclear which protocol offers superior short-term strength gains (Gibala et al., 2012).

## **Methodology**

### *Participants*

A total of eight collegiate students from Universiti Teknologi MARA (UiTM), Shah Alam campus, participated in this study, consisting of four males and four females. The participants were aged between 20 and 25 years old, with weights ranging from 60 to 80 kg and heights between 160 and 180 cm. All participants were classified as healthy adults, as they had a normal BMI, no pre-existing medical conditions or cardiovascular disorders, a minimum of three months of consistent resistance training experience, and were non-smokers. Individuals with chronic medical conditions such as diabetes, hypertension, or cardiovascular diseases, those currently taking medications affecting cardiovascular or metabolic parameters or those with a history of recent surgeries or musculoskeletal injuries were deemed ineligible for participation.

### *Outcome Measures*

This study employed a quasi-experimental design that included a pre-test, ongoing test, and post-test approach. Upper and lower body strength improvements were assessed using bench press and leg press exercise tests. The maximum weight successfully lifted during the final 5-repetition maximum (5RM) attempt for each test was recorded in kilograms.

In this study, multiple machines are employed. The bench press machine is designed for upper body strength training, specifically targeting the chest, shoulders, and triceps. It comprises a flat or adjustable bench, a barbell, and vertical or inclined guides. Users lie on the bench, grasp the barbell, and perform lifting and lowering movements to work the target muscles. On the other hand, the leg press machine is tailored for lower body strength training, focusing on the quadriceps, hamstrings, and glutes. Its structure includes a seat, a footplate, and a sled or platform on a guided track. Participants execute the exercise by sitting on the machine, pushing the footplate away to extend their legs, and providing resistance through attached weights.

For the bench press, participants began with a warm-up consisting of 10-12 repetitions using an empty 20 kg barbell, followed by a 1-minute rest. The weight was then gradually increased by 5-10% of the participant's body weight, aiming for momentary muscular failure (MMF) at 7-9 repetitions. After a 2-minute rest, the weight was further increased, and the process continued until MMF was reached. The maximum weight lifted during the final successful 5-repetition maximum (5RM) attempt was recorded. For the leg press, participants started with a warm-up of 10-12 repetitions using a lightweight load (approximately 50 kg), followed by a 1-minute rest. The weight was then increased by 10-20% of the participant's body weight,

targeting MMF at 7-9 repetitions. A 2-minute rest followed, and the weight was further increased to perform 6-7 repetitions leading up to the 5RM attempt. If the 5RM attempt was successful, participants rested for 2 minutes, and the weight was increased for subsequent attempts until MMF was reached. If the attempt was unsuccessful, the weight was decreased by 5-10% of the participant's body weight, and the 5RM attempt was repeated. The maximum weight lifted during the final successful 5RM attempt was recorded.

The EMOM workout protocol was conducted two days after the pre-test session. In the EMOM protocol, participants performed a specific number of repetitions for each exercise within a one-minute timeframe, using the remaining time in the minute for recovery. In this study, participants were required to complete 5 rounds of the following exercises: 20 repetitions of alternate dumbbell snatch, 15 repetitions of push-ups, 10 repetitions of jump-over burpees, and 5 repetitions of deadlift. After completing one round of all exercises, participants were given a 1-minute rest before starting the next round. Following the EMOM session, a 7-day washout period was applied to all participants to minimize carryover effects. After the washout period, the AMRAP protocol was conducted. In the AMRAP protocol, participants were tasked with performing a specific set of exercises as many times as possible within a 25-minute timeframe, without a predetermined rest period. The exercise sequence remained the same, including 20 repetitions of alternate dumbbell snatch, 15 repetitions of push-ups, 10 repetitions of jump-over burpees, and 5 repetitions of deadlift. Finally, a post-test session was conducted two days after completing the AMRAP protocol to evaluate the effects of the training sessions

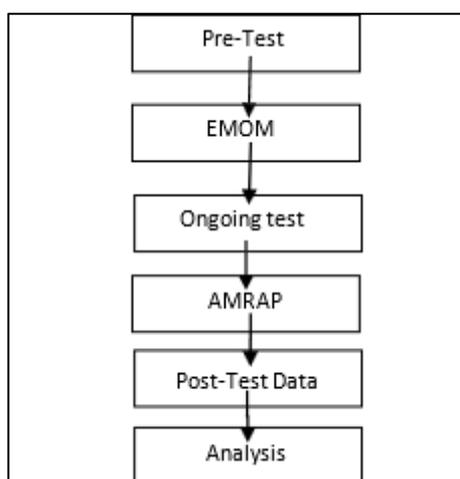


Figure 1: The procedures of data collection

Throughout both protocols, participants were instructed to maintain proper form to ensure safety and effectiveness. They were also encouraged to give their maximum effort to elicit the desired training response. The exercises were carefully selected to provide a balanced workout that would challenge participants' strength, endurance, and overall physical capacity. This structured approach allowed for a controlled comparison between the two CrossFit training protocols to determine their impact on muscle strength. This study was approved by the Faculty Ethics Review Committee (FERC), Universiti Teknologi MARA, under the reference number FERC1/1/2024(UG/MR/0359).

*Exercise Programme*

The exercise programme developed for this study compared the EMOM and AMRAP protocols in CrossFit training to assess their acute effects on muscle strength among healthy adults. The programme consisted of compound movements targeting multiple muscle groups, with a focus on both upper and lower body strength.

Participants were assigned two separate CrossFit sessions: one session following the EMOM protocol and another following the AMRAP protocol. Each session lasted 40 minutes and was structured into three phases: a 10-minute warm-up, a 25-minute training session, and a 5-minute cool-down. The primary distinction between the two protocols lies in rest time—EMOM incorporates a defined rest period within each minute, whereas AMRAP allows no predetermined rest intervals.

The training consisted of four compound exercises: alternate dumbbell snatches, push-ups, burpees, and deadlifts. Each exercise was performed with a controlled tempo of 3:1:3 (3 seconds for the eccentric phase, 1 second for the isometric phase, and 3 seconds for the concentric phase), except for burpees, which were performed at a steady pace. This structured approach allowed for the evaluation of muscle strength and endurance under varying training intensities and rest conditions.

Throughout both protocols, participants were instructed to maintain proper form to ensure safety and effectiveness. They were also encouraged to give their maximum effort to elicit the desired training response. The exercises were carefully selected to provide a balanced workout that would challenge participants' strength, endurance, and overall physical capacity. This structured approach allowed for a controlled comparison between the two CrossFit training protocols to determine their impact

Table 1

*EMOM Protocol*

<b>Exercise (4)</b>	<b>Reps</b>	<b>Load (lbs)</b>	<b>Rest Interval</b>	<b>Exercise Duration</b>
Alternate Dumbbell Snatch	20	<ul style="list-style-type: none"> <li>• 15lbs (Women)</li> <li>• 30lbs (Men)</li> </ul>		
Push Up	15	<ul style="list-style-type: none"> <li>• Modified (Women)</li> <li>• Regular (Men)</li> </ul>	1 min/round	5 rounds
Jump Over Burpees	10	Bodyweight		
Deadlift	5	<ul style="list-style-type: none"> <li>• 65lbs (Women)</li> <li>• 95lbs (Men)</li> </ul>		

Table 2

*AMRAP Protocol*

Exercise (4)	Reps	Load (lbs)	Exercise Duration
Dumbbell Snatch	20	<ul style="list-style-type: none"> <li>15lbs (Women)</li> <li>30lbs (Men)</li> </ul>	
Push Up	15	<ul style="list-style-type: none"> <li>Modified (Women)</li> <li>Regular (Men)</li> </ul>	25 min
Jump Over Burpees	10	Bodyweight	
Deadlift	5	<ul style="list-style-type: none"> <li>65lbs (Women)</li> <li>95lbs (Men)</li> </ul>	

*Data Analysis*

Participants' demographic data were analyzed using descriptive statistics, including mean (M) and standard deviation (SD). A one-way ANOVA was conducted to determine significant differences among the CrossFit protocols (EMOM, AMRAP, and Control). Additionally, the magnitude of change was calculated to assess the percentage difference between pre-and post-test results for each CrossFit protocol. The formula used for calculating percentage change is provided below.

$$\Delta\% = \frac{\text{Mean Post} - \text{Mean Pre}}{\text{Mean Pre}}$$

Statistical assumptions, including normality and homogeneity of variance, were tested to ensure reliable results. A significance level of .05 was set, meaning p-values below this threshold indicated meaningful differences. Data analysis was performed using IBM SPSS version 27, which provided both descriptive insights and inferential statistics to evaluate the effectiveness of each training protocol.

**Result and Discussion***Demographic Data*

Table 3

*Physical Characteristics of the Participants*

Physical Characteristics	Mean ± Standard Deviation
Gender	4 male and 4 female
Height	163.11 ± 9.81
Weight	57.89 ± 15.14
Muscle Mass	25.45 ± 6.75
Upper Body Strength	42.20 ± 19.98
Lower Body Strength	104.33 ± 30.85

*Comparison Effects Of Crossfit Protocol (Emom Vs Amrap) On Muscular Strength*

Table 4

*Multiple Comparison of Muscle Strength Scores between CrossFit Training Protocols*

Dependent Variable	Exercise (I)	Exercise (J)	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
						Lower Bound	Upper Bound
Upper Body Strength	AMRAP	Control	17.97	9.69	.18	-6.45	42.40
		EMOM	9.35	9.69	.61	-15.07	33.78
	EMOM	AMRAP	-9.35	9.69	.61	-33.78	15.07
		Control	8.62	9.69	.65	-15.81	33.05
	Control	AMRAP	-17.97	9.69	.18	-42.40	6.45
		EMOM	-8.62	9.69	.65	-33.05	15.81
Lower Body Strength	AMRAP	Control	17.01	15.70	.54	-22.58	56.57
		EMOM	10.21	15.70	.79	-29.38	49.79
	EMOM	AMRAP	-10.21	15.70	.79	-49.79	29.38
		Control	6.80	15.70	.90	-32.75	46.39
	Control	AMRAP	-17.01	15.70	.54	-56.57	22.58
		EMOM	-6.80	15.70	.90	-46.39	32.75

Both upper and lower body strength results indicated a  $p > .05$ , demonstrating no significant differences among the groups (EMOM, AMRAP, and Control). As presented in Table 4, it can be concluded that neither the AMRAP nor the EMOM protocols led to significant improvements in muscle strength.

*Magnitude of Change*

Table 5

*Percentage Change for Upper and Lower Body Strength between CrossFit Training Protocols*

Variable	Group	Magnitude of change (%)
Upper Body Strength	EMOM	25.85%
	AMRAP	53.89%
Lower Body Strength	EMOM	7.06%
	AMRAP	17.65%

The results indicate that both AMRAP and EMOM protocols show improvement in both upper and lower body strength compared to the Control group. The AMRAP protocol, in particular, showed the highest percentage increase in both upper (53.89%) and lower body strength (17.65%), suggesting AMRAP protocol may be more beneficial for developing muscular fitness compared to EMOM.

One of the most crucial parts of CrossFit training is High-Intensity Functional Training (HIFT) in which EMOM and AMRAP are the most frequently employed. This research aims to determine which CrossFit protocols might elicit the most effective techniques to enhance muscular strength due to differences in training structure between EMOM and AMRAP that might affect physiological adaptations.

This present study shows no significant difference between EMOM and AMRAP in improving upper and lower body strength. However, based on the magnitude of change, AMRAP shows a 28.04% greater improvement in upper body and a 10.59% improvement in lower body strength. This finding suggests that AMRAP may have the potential to generate greater benefits in strength development compared to EMOM in CrossFit training.

The descriptive statistics show the mean value for upper body score is 42.20 with a variability of 19.98 (Table 3). This suggests that some participants scored significantly higher or lower than the mean, indicating diversity in upper body strength within the participant group. Referring to the previous descriptive statistics result, it is observed that there are no significant differences in upper body muscle strength between all the CrossFit protocols (EMOM, AMRAP, and Control) due to the significance value that is greater than .05 (Table 4). The wide confidence intervals may reflect high variability in the data, possibly due to a small sample size. Even though there is no significant difference observed between EMOM and AMRAP, by referring to the magnitude of change ( $\Delta\%$ ), the AMRAP group shows greater improvement in upper body strength compared to EMOM. AMRAP protocol showed a greater improvement in upper body strength compared to the EMOM protocol by 28.04% (Table 5). The AMRAP protocol somehow might be more effective in improving muscular strength in both upper parts as it shows the highest percentage increase compared to EMOM.

The present study shows the mean value for lower body score is 104.33 with a variability of 30.85 (Table 3). This suggests that most participants achieved a higher or lower score and showed greater variability in lower body strength performance among the participants. Referring to the current finding, it is found that there are no statistically significant differences in lower body strength between all the CrossFit protocols (EMOM, AMRAP, and Control) due to the significance value that is greater than .05 (Table 4). Even though there is no significant difference observed between EMOM and AMRAP, however, referring to the magnitude of change ( $\Delta\%$ ), the AMRAP group shows greater improvement in lower body strength compared to EMOM. The magnitude of change calculations showed that AMRAP yielded a greater improvement in lower body muscle strength compared to EMOM protocol by 10.59% (Table 5). The AMRAP protocol somehow might be more effective in improving muscular strength in both upper and lower body parts as it shows the highest percentage increase compared to EMOM.

The study revealed that the AMRAP protocol demonstrated a greater potential to enhance muscular strength compared to EMOM. This is attributed to the unique characteristics of the AMRAP protocol, which involves high repetitions and a continuous, time-based approach. The repetitive and sustained nature of the protocol promotes muscular hypertrophy, defined as an increase in muscle fiber size due to the accumulation of mechanical tension, metabolic stress, and muscle damage during exercise. Hypertrophy plays a critical role in improving muscular strength, as increased muscle mass contributes to enhanced force production capabilities (Schoenfeld, 2010).

Research has consistently supported the relationship between hypertrophy and muscular strength. The physiological mechanisms underlying hypertrophy, such as the activation of satellite cells and protein synthesis, are directly linked to strength gains (Schoenfeld, 2010). AMRAP protocols, due to their high-volume nature, effectively stimulate type II muscle fibers,

which are primarily responsible for generating maximal force during strength-based activities. Furthermore, the continuous nature of the protocol increases time under tension, an essential factor in inducing muscle growth.

### **Conclusion**

In a nutshell, this research project successfully examined the acute impact of EMOM and AMRAP in CrossFit training protocols on muscle strength in healthy adults. Preliminary insights into the comparative effectiveness of these two popular workout regimens are provided. This finding shows a trend toward potential greater muscle strength improvements with AMRAP over EMOM. It also reveals the importance of considering individual variability in fitness responses and the need for personalized exercise programming to optimize muscle strength gains. Further research is recommended to confirm these findings and explore the long-term effects of these training protocols on muscle strength and overall fitness.

Future research should consider recruiting a larger sample size to enhance the statistical power and reliability of the findings. Additionally, implementing a randomized controlled trial design is recommended to improve internal validity by minimizing potential bias and controlling for confounding variables. Furthermore, future studies should explore the chronic effects of CrossFit protocols over an extended period, such as weeks or months, to assess their long-term impact. This approach would provide a more comprehensive understanding of the efficacy of these protocols for programme design and their potential benefits for overall fitness and performance.

### **Conflict of Interest**

The authors declare no conflicts of interest pertaining to this research. All authors have disclosed any financial, personal, or professional relationships that could be perceived as influencing the outcomes of the study.

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