Assessing the impact of a 4-week physical training regimen on cardiorespiratory fitness among firefighter recruits

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ABSTRACT

Introduction: Cardiorespiratory fitness is crucial for safe and efficient performance in executing firefighting tasks. The study aims to assess the effects of Phase 1 of a newly designed 4-week physical training regimen on changes in cardiorespiratory fitness, health parameters and other physical fitness elements. Phase 1 was crafted to primarily focus on improving firefighter recruits' cardiorespiratory fitness to prime their body for the subsequent phase of exercise.

Materials and Methods: A quasi-experimental study employing a one-group pre- and post-intervention was carried out involving 142 male firefighter recruits from a Fire and Rescue Academy in Malaysia. Various aspects of physical fitness changes, including speed, agility, and coordination (SAC), muscle strength, endurance, and power, were evaluated at baseline (Week 1) and upon completion of the first phase (Week 5). Changes in health parameters, such as blood pressure, resting heart rate, body weight, muscle mass, body fat percentage, and body mass index, were also assessed. A paired sample t-test was conducted with the significance level set at 0.05. The magnitude of changes was assessed using the following criteria: values of 0.3 were considered a small effect size, 0.5 indicated a moderate effect size, and 0.8 signified a large effect size.

Results: Upon completion of the first phase of the physical training regimen, there was a statistically significant improvement in cardiorespiratory fitness, with a mean increment of VO2max was 9 mL/kg/min (95% CI: 8.33, 9.58, p<0.001, large effect size of 2.40). Both pre-and post-intervention assessments of abdominal and upper body muscle strength and endurance showed statistically significant improvement with the mean difference of 11 sit-ups (95%CI: 10.08, 12.01; p<0.001, large effect size of 1.89) and 1.5 pull-ups (95%CI: 1.07, 1.86; p<0.001, moderate effect size of 0.63), respectively. Health parameters showed similar, except for systolic BP (SBP). There was a small increment in recruits' SBP following the 4-week training period with a mean difference of 4.3 mmHg (95%CI: 2.37, 6.24; effect size = 0.37, p<0.001).

Conclusion: The first phase of the newly introduced four-week physical training regimen has proven effective in enhancing cardiorespiratory fitness, as well as abdominal and upper body muscle strength and endurance. Additionally, the regimen has positively influenced several health parameters, except for systolic blood pressure. The observed increase in average systolic blood pressure indicates a necessity for continuous monitoring at the academy to address this issue effectively.
confirm our findings.

KEYWORDS:
Firefighters, physical fitness, cardiorespiratory fitness

INTRODUCTION

Firefighting is a high-risk profession that frequently exposes firefighters to hazardous and life-threatening situations. Therefore, maintaining optimal health and physical fitness is paramount for ensuring firefighters able to fulfil their duties safely and effectively.[1] Firefighters are required to be aerobically fit and have good total body strength and local muscular endurance to carry heavy equipment, climb stairs, carry out victims and move quickly while donning heavy protective gear. Given the physically demanding nature of firefighting, maintaining good physical fitness is instrumental in preventing musculoskeletal injuries and enhancing overall job performance.[1,2] Regular physical training is essential in achieving and sustaining this level of fitness.[3] Additionally, physical fitness training offers significant health benefits, including a reduced risk of heart disease and other chronic illnesses.[4]

Despite the imperative for firefighters to uphold optimal health and physical fitness, concerns persist regarding their current fitness status among stakeholders. Research indicates that firefighters may not engage in adequate physical activity and often lack the requisite fitness levels necessary for safe and efficient job performance.[5] In Malaysia, active firefighters are mandated to undergo the Individual Physical Proficiency Test (IPPT), a biannual physical fitness assessment.[6] However, despite these measures, the health parameters and physical fitness levels of firefighters in Malaysia remain, relatively, below the expected standard.[7] To address these concerns, the National Fire Protection Agency (NFPA) has established a set of health and fitness standards essential for executing 14 essential job tasks effectively.[8] Therefore, several guidelines have been established in western countries to implement structured

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physical training and fitness programs within fire academies and fire stations aiming to enhance and sustain firefighters' fitness levels.[9,10] One notable guideline is The Fire Service Joint Labor Management Wellness-Fitness Initiative (WFI), which has been integrated as a training program in selected firefighter academies in the United States.[10] Research indicates its effectiveness in improving the health and physical fitness of firefighter recruits.[11] In contrast, within the local context, there is a lack of documented guidelines for guiding the development of training regimens for firefighters. Consequently, the current physical training regimen lacks standardisation in its implementation and exhibits variability in practices, primarily driven by the individual preferences of physical training instructors at the Fire and Rescue Academy. This variance in training may result in significant differences in the health and physical fitness levels of recruits across different platoons during the 18-week firefighting training period. To address this issue, a four-phase physical training module has been developed, aiming to provide a standardized and structured physical training regimen. This training is administered under the supervision of trained and certified physical trainers at the academy.

Before proceeding with the implementation of subsequent phases (Phases 2 to 4) of the newly developed module, this study aimed to assess the effectiveness of a brief 4-week period of Phase 1 of the physical training regimen. Phase 1 of the module primarily focused on improving recruits' cardiorespiratory fitness, also term as aerobic or cardiovascular fitness, which refers to the functional capacity of an individual's lungs, heart, and blood vessels to deliver oxygen-riched blood to active muscles for consumption during sustained physical activity.[12] This was evaluated by measuring the completion time for a 2.4 km run, serving as one of the indicators for cardiorespiratory fitness status ascertainment. Additionally, this study examined changes in recruits' health parameters (such as blood pressure (BP), resting heart rate (RHR), body weight (BW), muscle mass (MM), body fat percentage (BF%), and body mass index (BMI)) and other physical fitness parameters (including speed, agility, and coordination (SAC), as well as muscle strength, endurance, and power).

MATERIALS AND METHODS

Study Design and Participants

This study utilized a quasi-experimental design with a one-group pre- and post-intervention method involving firefighter recruits. A convenient sampling method was employed, enrolling all male firefighter recruits (n=145) who joined the East Region Fire and Rescue Academy Malaysia on 1 February 2023. The initial enrolment exceeded the minimum predetermined sample size of 34 and was calculated using G*Power Version 3.1.9.7 for testing the mean difference between two dependent means of matched pairs. The calculation was based on an alpha error probability of 0.05, a study power of 0.80, and a hypothetical moderate effect size of 0.5.13 No female recruits were part of the intake. Before joining the academy, all recruits underwent pre-employment medical examinations and were certified medically fit by the attending medical officers.

The Physical Training Module

The new physical training module consists of four phases, implemented on a 6-day weekly schedule. The preliminary framework was developed by a panel of six experts, comprising three certified physical training instructors (PTIs) and three physical trainers (PT), the module was refined through a series of modified and extended Nominal Group Techniques (NGTs) from 19 to 23 June 2022. The modified NGT identified the three top-ranking exercises for functional strength required by firefighter recruits, including pushing, pulling, lifting, carrying, and dragging, as described elsewhere.[14]

The extended NGT represented a continuation of the effort to create a structured 6-day physical training regimen, building upon gathered insights from prior iterations of modified NGTs. They were tasked with crafting a daily physical training regimen starting on Saturday and ending on Thursday. The regimen should encompass the following aspects of functional fitness: 1) core strength exercises, 2) cardiovascular training sessions, 3) functional movements involving pushing, pulling, and carrying, 4) lower body exercises, combined with lifting, carrying, and dragging exercises, and 5) total body exercise incorporating core strength, cardiovascular endurance, flexibility, pushing, pulling, carrying, lifting, and dragging, to be included in the regimen at least once a week. They were reminded to incorporate dynamic stretching into warm-up and static stretching into cool-down routine. As a result of the extended NGT process, a daily exercise regimen was formulated, comprising a sequence of exercises tailored to individual repetition maximums and corresponding rest interval time.
Subsequently, the validation process was carried out by a panel of subject matter experts, comprising 5 certified PTIs, possessing equivalent experience and expertise to the previous module developers, alongside two senior firefighters. The validation process occurred from 29th November to 1st December 2022, with a focus on assessing the feasibility of the physical training regimen for firefighter recruits. Both the development and validation processes were moderated by a Public Health Medicine Specialist, supported by a senior firefighter officer from the Special Tactical Operation and Rescue Team of Malaysia, and aided by a doctoral student. Taking into account the feedback from the expert group during the validation process, the physical training regimen was expanded to four phases: beginner, also termed as Phase 1 (4 weeks), intermediate (8 weeks), final (4 weeks), and transition (2 weeks). Each phase of the module focuses on different aspects of physical fitness with a structured and standardised physical training regimen. The Phase 1, spanning four weeks, emphasizes the enhancement of recruits' cardiorespiratory fitness (Table I). During the initial two weeks of the training period, the majority of the training time was dedicated to aerobic exercises, with the remainder allocated to muscle-strengthening exercises. In the subsequent two weeks, equal time was allotted for both aerobic and muscle-strengthening exercises.

Table I outlines several types of aerobic activities combined with muscle-strengthening exercise variants (from regression to progression version) for muscle groups of legs, core of body, chest, and arms. On the one hand, several types of runs can attain moderate-intensity aerobic exercise, generally

Table I: Phase 1 of Physical Training Module Outline

Physical Training Regimen	Week 1	Week 2	Week 3	Week 4
Run (Long slow distance – with a pace that recruits can sing, Fartlek, circuit, interval run, tempo run), % of time	60	60	50	50
Muscle-strengthening exercise, % of time	40	40	50	50

Workout Time

Warm up: 15 mins, Training phase: 35 minutes, Cool down: 10 minutes

List of Muscle-Strengthening Exercise

Total Body Exercise	Upper Body Exercise	Core Body Exercise	Lower Body Exercise
• Burpee • Jumping jack • Star jump • Mountain climbers	• Push-up • Wide push-up • Diamond push-up • Full/elbow plank • Plank side • Plank arm/leg raise • Pike push-up • Shoulder taps • Arm scissor • Supine push-up • Downward-facing to upward-facing	• Superman • Single leg bridge • Sit-up • Crunch • Bike crunch • Sitting twist • Raise leg hold • Flutter kicks • Windshield wipers • Knee to elbow • V-ups • L-shape lifting	• Forward lunges • Jump lunges • Side lunges • Reverse lunges • Front & back lunges • Squat • Squat and jump • Sumo squat • Calf raise • Side-to-side shuffle • High knees

Table II: Health and physical fitness parameters of recruits at Week 1 and Week 5.

Variables	Week 1 Mean (SD)	Week 5 Mean (SD)	Mean Difference (95% CI)	t-statistics (df)	p-value	Effect size (d)
Health Parameters						
Systolic BP, mmHg	120.8 (13.04)	124.4 (11.16)	4.3 (2.37, 6.24)	4.4 (141)	<0.001*	0.37
Diastolic BP, mmHg	76.2 (9.18)	71.1 (7.67)	-5.2 (-6.65, -3.67)	6.9 (141)	<0.001*	0.58
Resting heart rate, bpm	86.9 (18.4)	68.6 (12.04)	-18.3 (-20.86, -15.78)	14.3 (141)	<0.001*	1.20
Body weight, kg	68.2 (9.26)	65.8 (7.02)	-2.3 (-2.87, -1.79)	8.6 (141)	<0.001*	0.71
Body Fat Percentage, %	16.2 (4.69)	12.8 (3.00)	-3.4 (-3.79, -2.97)	16.5 (141)	<0.001*	1.37
Body muscle mass, kg	54.0 (5.23)	54.4 (4.78)	0.4 (0.16, 0.64)	3.3 (141)	0.001*	0.28
BMI, kg/m^2	24.5 (3.00)	23.6 (2.19)	-0.8 (-1.02, -0.64)	8.6 (141)	<0.001*	0.70
Physical Fitness Parameters						
Speed, Agility, and Coordination:						
SR completion time, second	10.48 (0.67)	10.52 (0.88)	0.03 (0.08, 0.14)	0.6 (141)	0.531	0.04
Lower body explosive muscle power:						
SBJ distance, cm	206.0 (26.00)	206.3 (23.07)	0.3 (3.20, 3.72)	0.1 (141)	0.882	0.01
Abdominal muscle strength and endurance:						
SU, n number per minute	35.2 (7.28)	46.2 (5.51)	11.0 (10.08, 12.01)	22.6 (141)	<0.001*	1.89
Upper body muscle strength and endurance:						
PU, n maximum number	5.3 (3.39)	6.8 (3.32)	1.5 (1.07, 1.86)	7.3 (141)	<0.001*	0.63
Cardiorespiratory fitness:						
2.4km run time, minute	13.2 (2.05)	10.6 (1.41)	-2.6 (-2.87, -2.42)	23.3 (141)	<0.001*	1.92
Estimated VO_2max, mL/kg/min	40.9 (5.93)	49.9 (5.60)	9.0 (8.33, 9.58)	28.5 (141)	<0.001*	2.40

*p<0.05
Abbreviations: PU= pull up, SBJ= Standing Broad Jump, SR=Shuttle run, SU= Bent-knee sit-up

targeting for 65 to 75 per cent of the maximum heart rate. On the other hand, the chosen muscle-strengthening exercise involves multi-joint movements that effectively target the major muscle groups resulting in a perceived exertion rating ranging from level 3 (indicating moderate effort i.e. 65% effort) to level 4 (reflecting somewhat hard effort i.e. 70% effort).[15] This also aligns with achieving moderate-intensity aerobic exercise for recruits. The specified exercises are easily monitored to attain the moderate level of intensity recommended by the American College of Sports Medicine.16 Additionally, firefighters familiar with these exercises as they are a regular workout regimen.

The recruits' physical training sessions typically occurred in the morning and afternoon from Saturday to Thursday, each lasting an hour. The recruits were divided into 5 platoons. Each was supervised by four to five PTs trained in implementing this module, overseen by three PTIs. The PTs were given the flexibility to select the type of muscle-strengthening exercise to incorporate into the run. The PTs underwent training sessions from 12th to 15th December 2022, and from 29th to 31st January 2023 to ensure standardization in delivering the program.

Data Collection

Before data collection, the recruits received a short briefing regarding the purpose and scope of the study, and their informed consent was obtained. Authorization for the use of the health and physical fitness data was granted by the Planning and Research Division of FDRM. Ethical approval for the study was obtained from the Ethical Committee Board of The National University of Malaysia (Code: FF-2023-185).

Baseline data for various health parameters and physical fitness were collected during week 1, while post-intervention data were collected on the first day of week 5. Data collection for health parameters during both weeks occurred one day before the physical fitness test. Recruits were instructed to wear standard sports attire, comprising a short-sleeved white t-shirt, sports pants, and sports shoes.

Health Parameters

Height: Recruits' height was measured in metres using a portable stature meter to the nearest 0.01 m without wearing shoes in standing position and their back against the wall. Their height was mark at the level of head vertex. The distance from the floor to the mark was measured.

Systolic BP (SBP), Diastolic BP (DBP) and Resting Heart Rate (RHR): SBP (mmHg), DBP (mmHg) and RHR (beats per min, BPM) were taken as described using Innomed X1 Digital Blood Pressure Monitoring.[17] Recruits were instructed to sit on a chair with a backrest for a minimum of five minutes while in a relaxed state and refrained from speaking before measurements were taken.

Body Weight (BW), Body Muscle Mass (MM), and Body Fat Percentage (BF%): BW (kg), MM (kg) and BF% were measured using a bioelectrical impedance analysis machine, the Tanita Body Fat Analyser Model 701-BC554 (Tanita Corp., Tokyo, Japan). All measurements were conducted with recruits barefoot and empty pockets. Body weight and muscle mass were measured to the nearest 0.1 kg. Recruits who experienced a reduction in body weight of more than 3% at week 5 compared to week 1 were categorized as weight loss. Those with a body weight within 3% of the initial weight difference were considered to have stable weight, while recruits who gained more than 3% weight from the baseline were categorized as weight gain.[18]

Body Mass Index (BMI): BMI (kg/m^2) was calculated during analysis as body weight in kilograms divided by height in square meters.

Physical Fitness Parameters

Recruits' physical fitness was measured using five elements of the Individual Physical Proficiency Test (IPTT).[6] The IPPT was administered in the following sequence: shuttle run, standing broad jump, bent-knee sit-up, pull-up, and concluding with the 2.4 km run.

Shuttle Run 4 X 10m (SR): This test evaluates speed, agility, and partly motor skill coordination (SAC).[19] SR measures the ability to accelerate, decelerate, change direction and explode again to an individual top speed while maintaining excellent body control. The test involved placing two small brown tissue paper roll core tubes, each measuring 45mm in diameter x 100mm in height x 1mm in thickness, as line markers at a distance of 10 meters apart. The test required recruits to run back and forth between the two markers in four repetitions, covering a total shuttle run distance of 40 meters (4x10m), as quickly as possible. Additionally, recruits are required to pick up the paper roll core tubes as they turn to sprint back to the starting point. The duration for completing the entire circuit was measured to the nearest 0.01 second.

Standing Broad Jump (SBJ): This test evaluates the explosive muscle power of the lower limbs. It was a two-footed horizontal jump from a standing position at a line on the ground with their feet slightly apart. The distance between the starting line and the recruit's heels was measured to the nearest centimetre.

Bent-knee sit-up (SU): The SU test assesses the abdominal muscle strength and endurance of recruits. During the test, recruits laid flat with knees bent and feet firmly planted on the ground, while hands were positioned behind the earlobes. The recruit's partner held their feet securely. A sit-up was deemed complete when the recruit's elbows touched their knees and their back returned to the ground afterwards. The number of sit-ups performed by recruits within a minute was recorded.

Pull-up (PU): The PU test evaluates the upper body muscle strength and endurance of recruits. Recruits were required to grasp an overhead bar using a pronated grip, with arms fully extended. They then lifted their body until their chin was above the bar, before returning to the initial position with arms fully extended. The movement should be executed smoothly, without jerky motions, swinging the body, or kicking or bending the legs. The maximum number of complete PUs performed by recruits was recorded.

Cardiorespiratory fitness assessment using 2.4 km run time: The recruits were required to complete the run in the shortest time possible. The time taken to complete the 2.4km was measured to the nearest seconds. The estimated VO_2 max (Est. VO_2 Max) was calculated by using the following formula, based on the previous study.[20]

$$VO_2 \text{ max} = (483 / \text{run time in minutes}) + 3.5$$

VO_2 max, or maximal oxygen uptake, is a measure of the maximum amount of oxygen that an individual can utilize during intense exercise. It is typically expressed as millilitres of oxygen per kilogram of body weight per minute (ml/kg/min). The value of VO_2 max is considered one of the best indicators of cardiorespiratory fitness, also termed, aerobic fitness and endurance capacity.[21]

Data Analysis

The data were analysed using IBM SPSS version 27. Before analysis, all data were checked for normality using histogram and Q-Q Plot, skewness (-1 and +1) and kurtosis (-1 and +1). Descriptive analysis was performed and reported for all variables at week 1 and week 5. Following descriptive analysis, a paired samples t-test was conducted to determine the effect of a 4-week physical training regimen on health and physical fitness parameters with the significance level set at 0.05. Effect sizes were also reported to determine the strength of the difference between pre and post-intervention. The d effect sizes were interpreted as small (d = 0.2), moderate (d = 0.5) and large (d = 0.8).[23]

RESULTS

A total of 145 firefighter recruits were recruited for this study in week 1. Three recruits withdrew from the academy thus, were excluded from this study, leaving a final sample size of 142 firefighter recruits in week 5. Their mean age and height were 27 years old (SD=3.36) and 1.67m (SD=0.05), respectively. The descriptive analysis (mean and SD), results of bivariate analysis (paired t-test), and the effect size are presented in Table II.

Health Parameters

Results of comparison between pre and post-intervention for all parameters revealed statistically significant differences between before and after Phase 1 of the new module. All health parameters, except systolic blood pressure and MM, significantly decreased at week 5 in comparison to week 1. Furthermore, large effect sizes were observed for RHR and BF%. The BF% showed the highest effect size and MM had the lowest. Among recruits, 53.5% experienced weight loss, 35.9% maintained stable weight, and 10.6% showed weight gain.

Physical Fitness Parameters

Analysis of comparison for physical fitness parameters revealed significant changes between pre-and post-intervention for cardiorespiratory fitness, abdominal and upper body muscle strength and endurance. All three parameters increased significantly at week 5. The effect size for all significant parameters showed large effect sizes, except for PU, which has a moderate effect size of 0.63. As expected, both STR and SBJ had no significant improvement at week 5.

DISCUSSION

This quasi-experimental study aimed to assess the impact of a 4-week physical training regimen on cardiorespiratory fitness, along with various health and physical fitness parameters. The findings revealed significant changes induced by the physical training regimen across most health and fitness parameters, particularly in cardiorespiratory fitness. Contrary to our expectations, the SBP readings increased instead of decreasing. However, DBP and RHR demonstrated a significant reduction, consistent with findings from previous meta-analysis.[22] These changes were probably due to acute physiological adaptation as a result of aerobic training, which affects parasympathetic and sympathetic nervous activity, nitric oxide, the prostanoid system, the renin-angiotensin system, and vascular remodeling.[23] The unexpected rise in mean systolic blood pressure contrasts with expectations, given that aerobic training typically lowers vascular resistance through shear stress on the vascular wall. Aerobic exercise also triggers the release of growth factors and exerkines from skeletal muscles and organs, resulting in decreased vascular systolic blood pressure.[24] Previous studies have demonstrated the association between higher physical activity and fitness with lower blood pressure.[25] Although it has been shown that SBP increases with submaximal exercise workload, they are typically transient and would normalise during the recovery phase.[26] As recruits' blood pressure was measured after adequate rest in this study, the increase in blood pressure may be due to other factors that were not assessed in this study, such as psychosocial stress,[27] that may arise from the firefighting training itself, as demonstrated in previous study.[28] This demonstrates that the implementation of some interventions, such as blood pressure monitoring, may be necessary for recruits at the academy, as firefighters with elevated blood pressure are at higher risk of late onset hypertension and cardiovascular events.[29,30]

Consistent with previous findings,[31] BW, BMI, and BF% showed significant reduction while MM significantly increased. The reduction in BW, BMI and BF% can occur when an individual has a negative energy balance, which is when energy expenditure exceeds energy intake, and regular exercise causes increased energy expenditure when carried out regularly.[32] Regular aerobic exercise with the inclusion of a total body exercise has the effect of increasing muscle mass by causing muscle hypertrophy, which has been observed to occur in a short period of two weeks after initiation of training.[33,34] This causes an increase in muscle mass and would explain why some recruits had stable weight or weight gain. Furthermore, prolonged exercise leads to a decrease in body fat from the increase in lipolysis and fat oxidation.[35]

In this study, SAC and explosive power of the lower limbs showed no significant difference. These findings could be attributed to the design of Phase 1 of the physical training regimen which prioritized enhancing recruits' cardiorespiratory fitness rather than focusing on building lower body endurence and power. Phase 1 was crafted to prime cardiorespiratory fitness before progressing to Phase 2, an eight-week physical training regimen, focusing on developing muscle strength, endurance, and power of upper, middle and lower body muscle groups. High SAC can indeed aid firefighters in navigating the fire ground more effectively, especially during unpredictable and unforeseen circumstances.[36] By possessing enhanced SAC, firefighters can move with greater agility and efficiency, allowing them to respond quickly and adapt to changing conditions. This ability is crucial for firefighters as they manoeuvre through potentially hazardous environments, enabling them to better execute tasks and respond to emergencies effectively.[37]

The results indicate significant enhancement in both abdominal and upper body muscle strength and endurance when comparing week 5 measurements to the baseline at week 1, consistent with findings from previous studies incorporating aerobic and muscle-strengthening exercise programs.[31,37] Despite the primary focus of the initial phase to enhance cardiorespiratory fitness, the integration of total body exercises for muscle strengthening led to notable improvements in muscle strength and endurance of the upper body and abdominal core muscles. These improvements were evident even with once-per-week training sessions targeting specific muscle groups.[38] This phenomenon holds particular significance for untrained individuals, where rapid advancements in muscle fitness are largely attributed to neural muscle adaptation, a process likely facilitated by increased training frequency.[39]

This study reveals that by week 5, the average estimation of VO2 max significantly surpasses the recommended cardiorespiratory standard of 42 mL/kg/min outlined by NFPA.[8] Continuous exercise has been shown to enhance VO_2 max by increasing skeletal muscle mitochondrial content, myoglobin desaturation, and oxidative capacity.[40] Achieving this level of fitness equips firefighters to execute their duties safely while donning full firefighting gear and breathing apparatus, and it also serves as a protective factor against cardiovascular events.[1] Cardiorespiratory fitness is directly associated with the capacity to sustain dynamic, moderate-to-vigorous exercise involving large muscle groups.[21] Given the physically demanding nature of firefighting tasks, which place considerable strain on the cardiovascular system, maintaining optimal cardiorespiratory fitness is paramount. Enhancing cardiorespiratory fitness enhances firefighters' ability to perform tasks that demand sustained cardiorespiratory effort. Therefore, the decision to prioritize the improvement of cardiorespiratory fitness during the initial phase of training is justified.

This study demonstrates that significant improvements in the health and fitness parameters of firefighter recruits can be achieved within a 4-week physical training regimen utilizing only person’s bodyweight. Therefore, recruits can promptly commence exercising and seamlessly integrate it into their daily routines. Given the stringent selection process for firefighters, including thorough medical and physical screenings prior to academy acceptance, potential confounding factors such as underlying medical conditions were minimized. Furthermore, recruits in the academy adhere to a structured full-day schedule, reside in on-site accommodation provided by the academy, and receive standardized meals throughout the training period. These controlled settings effectively limit the impact of external physical activities and variations in nutritional intake on the study outcomes.

This study is subject to several limitations. Firstly, control group was not employed due to ethical and practical concerns. Withholding training from recruits could be perceived as unethical, considering the necessity to sufficiently equip them for the challenges of firefighting responsibilities. Secondly, the absence of female recruits in this study is notable. Future research should aim to include female firefighters, as training adaptations and outcomes may differ between genders. Lastly, the study was conducted in only one out of five academies in Malaysia due to technical constraints limiting the generalizability of the findings to the entire country. These limitations underscore the need for caution when interpreting and applying the study's results.

CONCLUSION

The initial phase of the newly implemented four-week physical training regimen has demonstrated success in improving cardiorespiratory fitness, abdominal, and upper body muscular strength and endurance. Additionally, the regimen has shown a significant impact on various health parameters, except systolic blood pressure. The observed increase in average systolic blood pressure indicates a necessity for continuous monitoring and implementation of intervention measures at the academy to address this issue effectively. This study also highlights that improvement in physical fitness can be achieved even with minimal equipment and cost. The module's effectiveness in improving body composition and physical fitness measurements sets a strong foundation for the subsequent phases, which are likely to build upon these improvements. Future studies should seek to replicate the findings in other Fire and Rescue Academies to gain a thorough knowledge of the module's efficacy and adaptability in various settings and larger samples.

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