PUBLIC HEALTH RESEARCH

Development of Physical Training Program to Boost Functional Strength in Firefighter Recruits Using a Modified Nominal Group Technique

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ABSTRACT

Introduction A series of comprehensive focus group discussions with active firefighters revealed that inconsistencies in incorporating a rigorous physical training program during work hours contributed significantly to the challenges of maintaining functional fitness, particularly strength. This article outlines a process for identifying the specific exercises required to enhance strength, drawing on the expertise and experience of physical trainers.

Methods Modified nominal group technique (mNGT) sessions were conducted to identify and rank exercises for five functional strengths (i.e., pushing, pulling, lifting, carrying, and dragging). A total of six physical trainers from the firefighter academy were interviewed to 1) identify the skeletal muscles involved in the functional movements using a visual aid; 2) generate ideas for exercises via brainstorming; 3) privately rank the displayed list of exercises for each muscle group involved in each functional movement; and 4) design a physical training programme for beginner, intermediate and advanced levels by manipulating loads.

Results Males dominated the expert group (66.7%) and had a mean of 11.50 (SD 5.20) years of experience in physical training. The mNGTs yielded three top-ranking exercises for each functional strength: 1) Pushing: the push-up, sit-up, and jumping jack; 2) pulling: the push-up, jumping jack, and sit-up; 3) lifting: the jumping jack, push-up, and jumping squat; 4) carrying: the push-up, plank, and sit-up; and 5) dragging: the jumping jack, sit-up, and jumping squat. Then each exercise was designed for the beginner, intermediate, and advanced levels by manipulating loads (i.e. additional weight or number of repetitions).

Conclusion This study demonstrated that mNGT is an effective tool for identifying the three top-ranking exercises that address firefighter recruits' functional strength. The experts chose multi-joint exercises targeting agonist and antagonist skeletal muscle groups and mimicking movements of daily work life. The exercises, corroborated by previous empirical evidence, provide opportunities for common skeletal muscle groupings to be targeted simultaneously to increase cardiovascular adaptations over a shorter period. The physical exercise is now ready to be implemented for piloting purposes among firefighter recruits.

Keywords Firefighter Recruits; Functional Movements and Strength; Physical Exercise; Modified Nominal Group Technique

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INTRODUCTION

Firefighting is a physically demanding job requiring firefighters to have an optimal level of physical fitness to execute essential job tasks, which include various types and levels of emergency services provided to the local community. Firefighter experts[1] have advocated focusing on functional training to improve the eight components of firefighter physical fitness: core strength, cardiovascular capacity, flexibility, and the firefighting-specific functional movements of pushing, pulling, lifting, carrying, and dragging. These functional movements require adequate stabilization and core strength, and none of them isolate individual muscle groups. Firefighting tasks can include pushing and pulling equipment horizontally or vertically, lifting and carrying heavy objects (9 to 18 kg) or victims ranging from newborns to adults weighing more than 75 kg, and dragging water-filled hose lines (estimated weight of 117 kg per 100 feet of length for a 2.5-inch diameter hose during fire ground operations. The demands of these functional movements thus require firefighters to have consistent muscular strength, endurance, and power to ensure effective task performance under stressful conditions in extremely hot environments for the duration of the fire. Unlike the ACSM guidelines for the general population, which melded muscular strength, endurance, and power into a single category termed muscular fitness,[2] the firefighter's book writers created a specific category for firefighter functional strength.[1]

Persistent functional strength is not built in a day; its development requires a consistent process, cumulative efforts, and high self-discipline in complying with a physical training (PT) program. Amazingly, existing PT practices are heterogeneous and ambiguous in their methods of combining different exercises to suit the targeted muscle groups and enhance functional strength,[3] a finding that has been corroborated in additional research[4] and recent focus group discussions.[5] This alarming state of PT practice catalysed us to design an objective-driven PT program that nurtures firefighter-specific functional strength to ensure lifelong functional fitness. Employing a program of this type for firefighter recruits provides a unique opportunity to ingrain PT principles, as recruits are inexperienced, malleable, and obedient, which optimizes their ability to adopt lifelong fitness routines and consequently pass their physical fitness tests with excellence. In Malaysia, firefighter physical fitness is assessed via a 2.4 km run, bent-knee sit-up, standing broad jump, pull-up, and 4 x 10 m shuttle run to determine cardiovascular capacity, abdominal muscle strength, explosive lower limb power, upper body strength and endurance, and speed, agility and coordination, respectively.[6] Hence, PT programs should be designed and fine-tuned based on the desired outcome of deployable firefighters equipped with tactical athletes.

Being deployable requires the fulfilment of a set of functional fitness criteria. According to a well-known benchmark,[7] a firefighter should attain a minimum VO_2max of 42 mL/kg/min to perform fire suppression tasks for the duration of a fire while wearing full gear and a self-contained breathing apparatus (SCBA). This benchmark is supported by empirical evidence from more than three decades ago.[8] The value is higher than the suggested average VO_2max of 31.5 mL/kg/min, which was derived from eight reported studies.[9] The higher VO_2max requirement is due to the SCBA, which impairs ventilatory mechanics and reduces firefighters' maximal oxygen consumption, requiring them to adopt different respiratory patterns, particularly when working in challenging environments such as high-rise buildings. Other functional criteria for deployable firefighters include the ability to lift and carry objects (equipment or human) as heavy as their body weight to a safer area without assistance.[1]

Functional stabilization of the lower body, another criterion of a deployable firefighter, is defined as the firefighter's ability to maintain body stability and move forward while holding and dragging a pressured water-filled hose line or walk far distances at an incline or decline while carrying heavy objects, completing the round-trip journey without stumbling.[10] These functional criteria require two of the three components of functional strength (i.e., muscular strength and endurance but not explosive muscular power). A balanced transaction between load and repetition during PT is crucial to developing these elements. The development of a PT program that balances load and repetition and appropriately matches exercises to critical muscle groups requires an in-depth understanding of essential firefighting tasks.

This study aimed to employ a modified procedure of the traditional nominal group technique in a group of physical trainers to identify the exercises that address the five functional firefighting movements and incorporate the exercises into a firefighter recruit functional strength PT program. It is also meant to facilitate a consensus among the trainers regarding the load and repetitions needed for exercises addressing specific muscle groups to boost the performance of the five functional firefighting movements.

METHODS

Study Design, Site, Sampling and Participants

This study was an exploratory qualitative study of a physical trainer group that evaluated their experiences, perspectives, and knowledge regarding the types of exercises that target the muscle groups involved in the five functional firefighting movements. The trainers were selected from the Fire and Rescue Academy of Malaysia in the eastern

region. They were chosen via a "gatekeeper" using a purposive sampling method to ensure a broad spectrum of perspectives and opinions on the topic based on participants' experience and skills. The gatekeeper was a person with in-depth information and access who identified the appropriate physical trainers to be recruited for participation in the expert group discussions relating to the best exercises to utilize in PT. Inclusion criteria for recruitment were as follows: 1) current physical trainer with at least 5 years of experience, and 2) directly involved in PT activities and had rich experience in handling firefighter recruits. A total of six participants were recruited, a mix of certified PT instructors and physical trainers, who were directly involved in 18-week PT programs. The sample size of six participants was deemed adequate, as verified by previous guide requiring two to 14 participants [11]. We predicted that we would obtain exhaustive ideas from the participants due to their involvement in 2-hour PT sessions of 6 days per week for recruits.

Data Collection

Tool

The gathering of data was guided by an interview protocol composed of open-ended questions (Table 1).

Table 1 Questions for mNGT

Area to cover	Question
Identify muscle involved in five functional movements and its matching exercise to improve the muscle strength and endurance	Using Figure 1 as a vision aid:
Pushing movement	In reference to the picture showed, which muscle is involved in pushing movement (pushing muscle group)?", "Is this muscle? (Show one by one from top to bottom for front and hind view). How to exercise the muscle (single or a combined muscle group)?
Pulling movement	In reference to the picture showed, which muscle is involved in pulling movement (pulling muscle group)?", "Is this muscle? (Show one by one from top to bottom for front and hind view). How to exercise the muscle (single or a combined muscle group)?
Lifting movement	In reference to the picture showed, which muscle is involved in lifting movement (lifting muscle group)?", "Is this muscle? (Show one by one from top to bottom for front and hind view). How to exercise the muscle (single or a combined muscle group)?
Carrying movement	In reference to the picture showed, which muscle is involved in carrying movement (carrying muscle group)?", "Is this muscle? (Show one by one from top to bottom for front and hind view). How to exercise the muscle (single or a combined muscle group)?
Dragging movement	In reference to the picture showed, which muscle is involved in dragging movement (dragging muscle group)?", "Is this muscle? (Show one by one from top to bottom for front and hind view). How to exercise the muscle (single or a combined muscle group)?

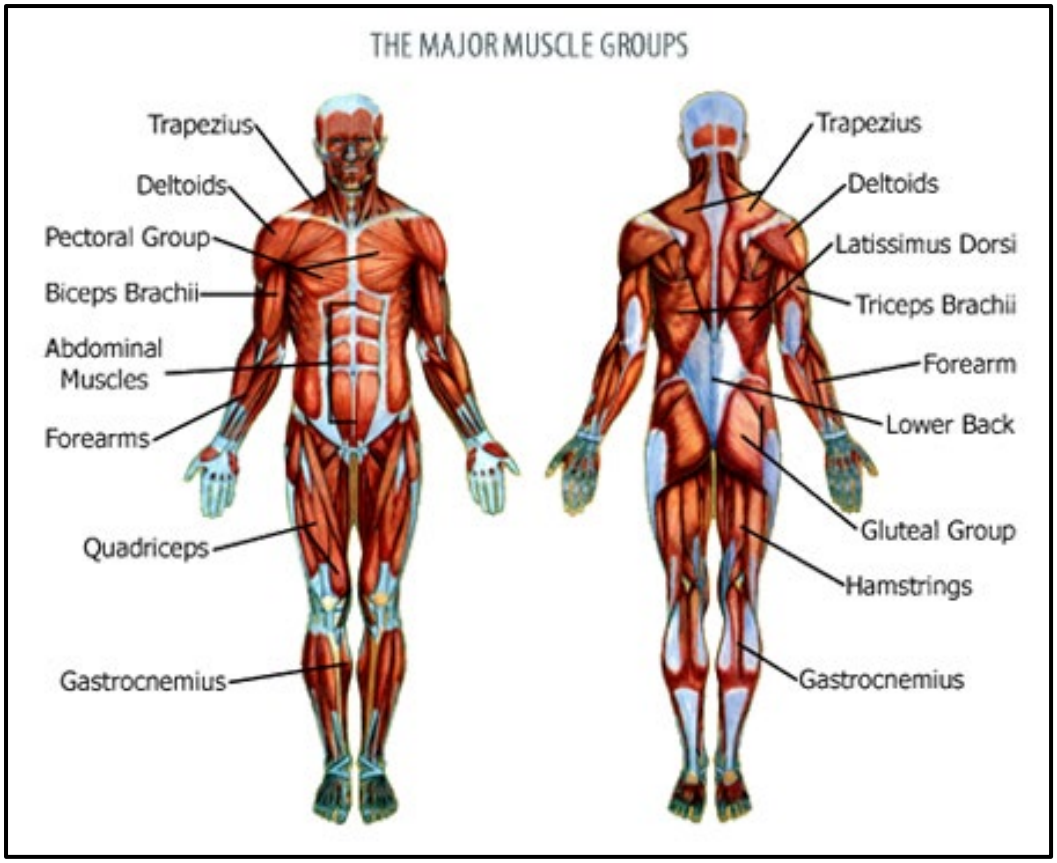

Figure 1 Human body with major muscle groups[12]

This method allowed for the building of trust between the health researchers and trainers through spending time together and sharing experiences, which increased the acceptability and effectiveness of the designed PT program.

Modified nominal group technique, mNGT

The Nominal Group Technique (NGT) was utilized as the primary method of data collection for this study. This approach is ideal for allowing individuals to express their thoughts and ideas, gather responses in a structured manner, and reach a consensus through the prioritization of ideas and suggestions. As a powerful tool for gathering the necessary information to design a comprehensive physical training (PT) program, it enabled the development of 2-hour sessions to be performed six days per week to physically prepare recruits for firefighting duties. The NGT method eliminates laborious and resource-intensive transcription protocols, and the specialized skills required for transcription data analysis, thus facilitating rapid decision-making and the quick determination of solutions. We replicated the NGT protocol reported previously [11,13] but modified it to capture individuals' priorities and ensure equitable participation, referring to this as the modified NGT (mNGT). The modifications did not deviate significantly from the original method. The mNGT was designed to explore participants' knowledge and opinions regarding the involvement of skeletal muscle groups in the five functional firefighting movements (pulling, pushing, carrying, lifting, and dragging) using a visual aid. It also aimed to identify exercises targeting specific muscle groups and prioritize these exercises through a ranking system. The top three prioritized exercises were then adapted to normal, progressed, and regressed versions for beginner, intermediate, and advanced difficulty levels. Two mNGT sessions were conducted on consecutive days, June 20 and 21, 2022. Day 1 focused on the pulling and pushing muscle groups, while Day 2 addressed the lifting, carrying, and dragging muscle groups. Each mNGT session included a face-to-face discussion among the expert group that lasted approximately three hours. Exercises to enhance explosive muscular power for striking structures during entry/exit were not explored, as such power is rarely employed. This study obtained approval from the Universiti Kebangsaan Malaysia Research Ethics Committee (approval no. JEP-2020-804).

Preparatory tasks prior to modified nominal group technique sessions.

Prior to the mNGT sessions, the lead researcher developed a series of structured questions (Table 1) and created PowerPoint images depicting the human

body and its major muscle groups (Figure 1). Additionally, the lead researcher conducted a brief training session for the research team members to ensure a smooth progression through each step of the mNGT process. During the sessions, the lead researcher served as the moderator, while a graduate student researcher recorded the participants' responses. The meeting took place in a quiet room at the academy, chosen for its conducive environment. The chairs and table were arranged in an oval shape to facilitate easy viewing of each other and the projected PowerPoint presentation. The spacious room provided a comfortable atmosphere for the discussion.

During modified nominal group technique sessions

At the beginning of the modified Nominal Group Technique (mNGT) session, the moderator facilitated a 15-minute ice-breaker activity to encourage participant interaction, followed by an introduction session. Participants introduced themselves by name, years of service, and qualifications in the physical training (PT) field. The moderator emphasized the research objectives and expected outcomes, provided the research informational sheet, and collected signed consent forms. The discussion commenced with the moderator delivering the opening statement in Malay to clarify the participants' roles. They stressed the importance of each expert's contribution and explained how their input would be used to develop a PT program aimed at enhancing the fitness levels of firefighter recruits. Each expert was given A4 paper and a pen to write and rank their responses.

The steps that comprised the mNGT protocol are outlined below and summarized as shown in Figure 2.

1) Identify skeletal muscles involved in functional movements using a visual aid

The modified Nominal Group Technique (mNGT) session began with the projection of an image of the human body highlighting its major muscle groups (Figure 1). The experts were then asked specific questions for each functional movement, starting with: "In reference to the picture shown, which muscle is involved in the pulling movement (pulling muscle group)? Is this muscle?" The moderator pointed to each muscle from top to bottom for both the anterior and posterior views. To optimize the efficiency of the process, the experts were asked to raise their hands simultaneously to indicate their agreement with the identified muscles. This method facilitated a structured and consensus-driven identification of the muscle groups involved in each functional movement.

2) Generate ideas

In this step, the experts were asked to list exercises that target each functional muscle group until all ideas were exhausted. This process was facilitated by the prior acknowledgment of the correct muscle groups involved in each functional movement, as depicted in Figure 1. The graduate student researcher collected all the listed exercises. When similar exercises were proposed, they were clustered together with the experts' permission. The compiled exercises were then displayed for use in step 3.

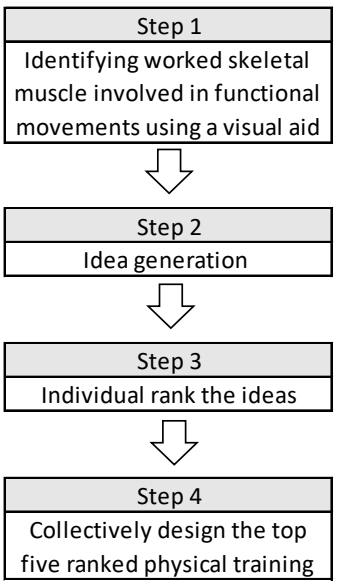

Figure 2 Flow of mNGT

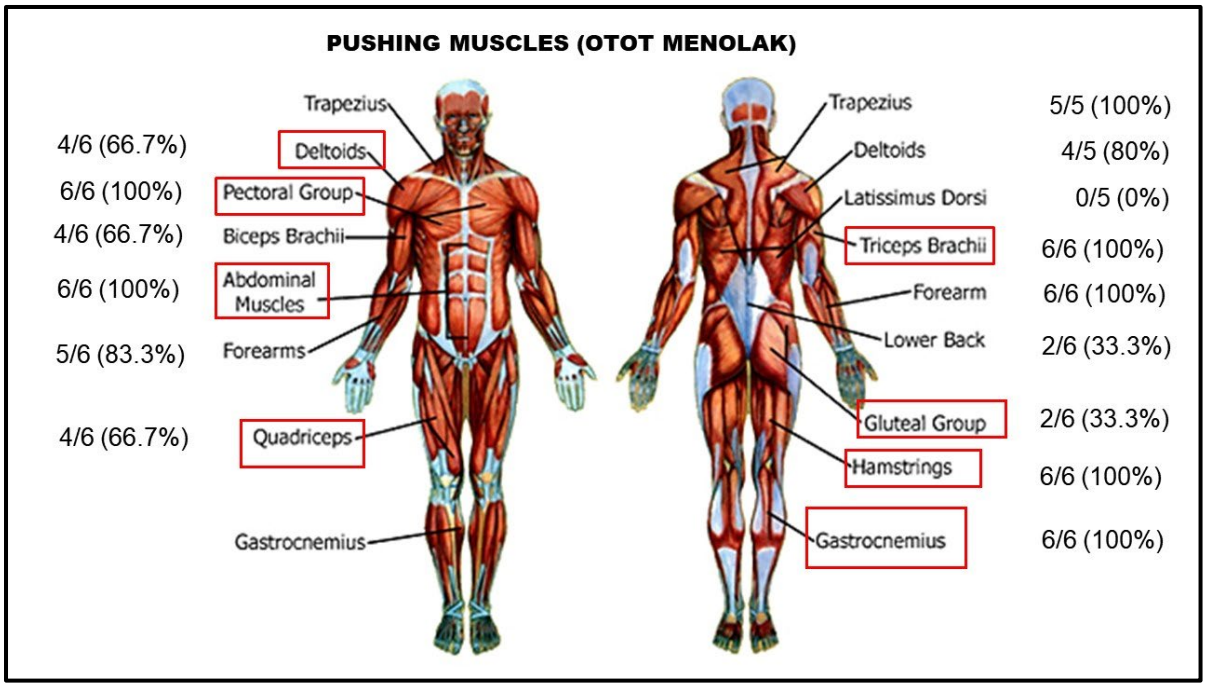

Figure 3 Correctness in identifying muscles involved in pushing movement[12]

3) Rank the ideas

The moderator instructed the experts to privately rank the displayed list of exercises for each muscle group involved in each functional movement, from highest to lowest priority. The experts wrote their responses anonymously on individual response sheets, assigning an ordinal number to each exercise, with smaller numbers reflecting higher priority. Each response sheet was then collected, and the recorded numbers were summed on a projected Microsoft Excel sheet. Lower summation scores indicated a higher priority for the exercise within the functional movement.

4) Design physical training programme for beginner, intermediate and advanced levels

The top three exercises for each functional movement identified in step 3 were selected to design PT programs for beginner, intermediate, and advanced levels. The participants collectively developed normal, progressed, and regressed versions of these exercises, tailored to the three difficulty levels. The difficulty levels were distinguished by the number of repetitions and/or the degree of load, progressing from body weight to the external load of firefighting equipment. The firefighters' body weight was considered their one-repetition maximum (1RM), or the maximum load they can lift for one repetition during training. The firefighter experts proposed using heavier loads (80%–100% of 1RM) with fewer repetitions to develop muscular strength, and lighter loads (50%–70% of 1RM) with more repetitions to build muscular endurance. The program primarily focused on female recruits, with male experts cross-checking the intensity levels with their female counterparts to ensure the exercises matched the performance capabilities of female recruits. These four steps were repeated for all five functional firefighting movements (Table 1).

Statistical Analysis

The group data, encompassing age, years of service, and PT experience, were analysed using descriptive statistics in IBM SPSS version 29. The resulting data were expressed in terms of range and dispersion, including mean and standard deviation (SD). The correctness of the response was calculated based on the number of raised hands whenever a muscle was shown on the visual aid. This was reported as a percentage (%) for each muscle shown (Figure 3). Subsequently, the values were manually averaged for the correct muscles involved in each functional movement.

RESULTS

The group of participating experts was dominated by males (66.7%), and three participants were certified PT instructors. The age range of the participants was 31 to 42 years, with a mean age of 36.5 years (SD 4.1). The mean years of service and PT experience were 12.7 years (SD 4.2) and 11.5 years (SD 5.2), respectively.

Mr E1 had 11 years of experience in the field of recruit PT and was highly motivated to pursue his interest to the highest level of achievement. He had a current professional certification as a Master Instructor and periodically attended sports science courses to upgrade his physical fitness license. Mr E2 had 5 years of

experience in the field of recruit PT. He attended sports science courses and was certified as a Level 1 Trainer. Mr E3 had 15 years of experience in the field of recruit PT. He had a strong knowledge about difficulty level of the training exercise to be prompted in the study based on his experience when guiding the recruits on the marching field. Mrs E4 had 15 years of experience in the field of recruit PT. She was a certified aerobics instructor and attended fitness courses regularly. Mrs E5 had 14 years of experience in the field of recruit PT and attended fitness courses regularly, and Mr E6 had 5 years of experience in the field of recruit PT. All experts provided valuable information throughout the mNGT sessions. The female experts always informed the group regarding female recruits' exercise capabilities, in timely manner.

The average percentages of correct responses when identifying the muscles involved in each functional movement were inconsistent. On average, the experts correctly recognised most muscles involved in pulling (90%), pushing (83.3%) (Figure 3), dragging (77.1%), carrying (66.7%), and lifting (54.5%). The mNGT yielded the three highest-ranking exercises for the muscle groups involved in each functional movement. For pushing (Table 2), the top exercises were the push-up, sit-up, and jumping jack; for pulling, the top exercises were the push-up, jumping jack, and sit-up; for lifting, the top exercises were the jumping jack, push-up, and jumping squat; for carrying, the top exercises were the push-up, plank, and sit-up; and for dragging, the top exercises were the jumping jack, sit-up, and jumping squat. Each selected exercise was then assigned normal, progressed and regressed versions for beginner, intermediate and advanced difficulty levels by adjusting body weight, full gear and/or firefighting equipment loads (Table 3). The push-up, sit-up, and jumping jack exercises were frequently listed by the participants.

Table 2 Ranking the idea

Bil.	The matching exercise for pushing movements	Participants' ranking						Total	Group Rank
		A	B	C	D	E	F		
2	Push up	3	2	3	1	5	1	15	1
3	Sit up and its variations	1	7	2	3	3	3	19	2
1	Jumping jack	4	4	1	2	14	2	27	3
6	Squat and its variations	6	8	5	4	2	5	30	4
7	Burpees	5	1	7	10	1	6	30	5
4	Plank and its variations	2	6	4	6	4	14	36	6
5	Lunges	7	5	6	9	13	4	44	7
12	Variation with medicine ball	10	11	15	5	9	10	60	8
11	Lizard crawl (merangkak biawak)	11	10	12	12	8	9	62	9
13	Straighten arm	13	13	8	7	10	11	62	10
8	Glutes bridge and its variations	9	14	10	13	12	7	65	11
10	*Dongak harimau*	12	9	9	15	7	15	67	12
15	Leg lift/raises	14	12	14	8	6	13	67	13
9	Mountain climb	8	15	11	11	15	8	68	14
14	Airborne exercise	15	3	13	14	11	12	68	15

	Muscles	How to exercise the muscles		
		Push up	Sit up and its variations	Jumping jack
		Ranking 1	2	3
Chest	Pectoral group	X		X
Shoulder	Deltoids	X		X
Arm	Triceps	X		X
Core	Abdominal muscles	X	X	X
	Muscle attaching to spine or pelvis	X	X	X
Legs	Gluteal groups	X		X
	Harmstrings	X		X
	Gastrocnemius	X		X
	Quadriceps	X	X	X

Level	**Beginner**	RM20 - 30 of normal push up; Progress: wide--> diamond; Regress: laying on upper part of knee	1st week (correct technique thus reduce RM) - RM 10-20 x 1 set, Progress - add 2-3 sets; Regression - half sit up (45 degree or less) --> 45 degree static	RM 10 -30
	Intermediate	RM30-50. Inclined push up; Progress- add RM (10), Regress - reduce RM (3-4);	RM 20-30. add 3 sets. Progress - sit up 45 degree than touch ankle to ankle; regress - normal sit up	RM 31-60
	Advanced	RM >50. Progress: normal push up add weight, Regress: Inclined push up add weight for example hose 2.5 inches (Note: 1 hose = 20 kg),	RM 1-3. Add Sit up touch toe, V shape touch (based on self ability); Progress - 1 to 3 set; Regress back to intermediate. Intermediate add weight (hose or medicine ball)	RM 61 -100

Figure 4 Pushing muscle and its matching exercise

DISCUSSION

This study aimed to gain an expert consensus on the best exercises for specific muscle groups to incorporate into PT programs aiming to enhance the five areas of functional strength in firefighter recruits. The top three exercises for each functional movement, as ranked by the participants, were the following: for pushing, the top exercises were the push-up, sit-up, and jumping jack; for pulling, the top exercises were the push-up, jumping jack, and sit-up; for lifting, the top exercises were the jumping jack, push-up, and jumping squat; for carrying, the top exercises were the push-up, plank, and sit-up; and for dragging, the top exercises were the jumping jack, sit-up, and jumping squat. These exercises are functional, multi-joint exercises that target agonist and antagonist skeletal muscle groups and mimic movements of daily life for firefighters. The identification of these exercises facilitates PT planning, allowing common groupings of skeletal muscles to be targeted simultaneously to enhance core strength and cardiovascular adaptations. Each exercise was assigned modifications according to individuals' ability by manipulating load by body weight and firefighting equipment or adjusting repetitions. Although the push-ups, sit-ups, and jumping jacks were frequently listed by the participants, this discussion highlighted only the push-ups and jumping jacks as a central pillar of discussion. These two calisthenic and vigorous-intensity exercises (defined as having an energy cost of 8 kcal/kg/hour) are often used for disciplinary purposes during recruitment.

The push-up was a frequently listed exercise for addressing the pushing, pulling, lifting, and carrying movements. It is a fast and effective exercise that directly targets the strength and endurance of the chest, shoulders, arms, and core muscles and indirectly targets the quadriceps and hamstring muscles depending on the type of push-up performed and its variations, frequency and intensity. Hence, using this exercise, multiple areas of functional strength for firefighters can be repeatedly addressed over 8 weeks of training. In this study, the participants suggested that the push-up exercise and its variations, using body weight for beginner and intermediate levels and firefighting equipment for advanced levels, were beneficial for improving upper body functional strength. The experts favoured standard push-ups over the knees-bent version because it looks more heroic and effective, which has been corroborated in a previous review. A team of researchers demonstrated that standard push-ups and the knees-bent version elicited a ground reaction force of 64% and 49% of the exerciser's body weight, respectively, while the exerciser is in the starting position.[14] Thus, the standard push-up is superior to the knees-bent version, and the weight supported by the arms is more than the load of 60% of the 1RM recommended for strength training. Often, the knees-bent version was chosen as a regression. However, both the standard push-ups and the knees-bent version have been shown to induce muscle hypertrophy and muscle gain when they are performed to failure and produce similar isometric strength, findings that have been supported in recent research.[15] To improve local muscular endurance, the experts set 30, 50, and more than 50 repetitions as the volitional failure cut-off points for the beginner, intermediate, and advanced levels. These values correspond to the normative value for above-average (30–39 repetitions) to excellent (> 47 repetitions) push-up norms for men aged 20–29 years.[16] Interestingly, the chosen cut-off points may have multiple applications. The push-up has been identified as a protective health indicator for cardiovascular disease (CVD) events within 10 years. A group of researchers[17] reported that across a sample of 1,562 active firefighters, those who completed more than 40 push-ups were 96% less likely to experience a CVD event compared to those who completed fewer than 10 push-ups (IRR, 0.04; 95% CI, 0.01–0.36). The researchers further revealed the number of push-up repetitions to be a better cardioprotective factor than a VO_2max of greater than 42 mL/kg/min.

In this study, the experts identified the weighted standard push-ups as a progression for the advanced level. A roll of empty fire hose with a diameter of 2.5 inches (estimated weight of 20 kg per 100 feet) placed on the upper back increases the load on the straightened arms by 20 kg (i.e., 28.5% load increase relative to body weight). If the recruit's weight is 70 kg, the total load on the upper limbs is 64.8 kg while performing the push-up. The weighted push-up targets the shoulder muscles (anterior deltoids) and increases the activation of the stabilizing core muscles. No repetition maximum was suggested, consistent with a previous empirical study.[18] In the Fire and Rescue Academy of Malaysia, the decision regarding the number of repetitions to prescribe is dependent on the experience and creativity of the physical trainer after observing the recruits' performance ability. Heavy loading can be coupled with short rest periods in circuit training, resistance-based interval training, or high-intensity functional training programs to meet specific physical demands for the desired functional fitness goals. Providing short rest intervals (60–120 seconds) between exercises appears to be a practical strategy that allows recruits to recover enough to achieve greater workloads in the next exercise, leading to improvements in the targeted muscle groups. While firefighter recruits should be trained for the most strenuous scenario they might encounter, they should not be trained as athletes who require explosive power for athletic performance. Thus, we did not explore exercises training upper body power with the intent to move as rapidly as

possible through the full range of motion, as firefighting activity relies less on how powerful a muscle is. They rely more on how long the muscles can endure while performing essential heavy tasks at more than 7 metabolic equivalents of task (METs) during a fire period. In Malaysia, a fire period can be as short as 30 minutes for a residential fire and as long as 14,400 minutes for a bushfire[19]

The second frequently reported exercise was jumping jack. The exercise that targets the muscles involved in pushing, pulling, lifting, and dragging. The jumping jack is a simple, whole-body aerobic exercise that involves jumping in place while coordinating the swinging of the arms and legs. This versatile conventional exercise works the lower body (i.e., gluteus maximus, hip flexors, quadriceps, and hamstrings), upper body (i.e., shoulder muscles, including anterior, and posterior deltoid), and abdominal muscles. The intensity can be progressed or regressed depending on the individual's physical needs by adjusting the jump height or speed. The jumping jack is frequently performed for as many repetitions as possible or is interspersed with other whole-body intensive exercises, such as burpees, squats, and mountain climbers. The benefits of this exercise include developing muscular strength and power of the lower body, improving cardiovascular fitness and burning calories. The development of absolute lower body strength may best prepare firefighters for occupational tasks that require their lower extremity muscles to generate force while pulling hoses, carrying equipment upstairs, conducting forcible entries, and dragging victims to safety.[20] A recent study[21] showed that jumping jacks improved heart rate variability and decreased resting heart rate. This exercise promotes positive adjustments in cardiac autonomic modulation by reducing sympathetic modulatory influence and/or increasing vagal modulatory influence on the heart, thus increasing heart rate variability, which is associated with a lower risk of CVD.[22]

The jumping jack has an MET rating of 8 if performed at a high intensity.[23] For firefighter recruits, the count of 1, 2, 3, 1 is considered one jumping jack in 2 seconds, for an average of 30 jumping jacks in 1 minute (and 60 jumping jacks for the general population). Employing increments of 30 repetitions for the different intensity levels eases the monitoring of timing and the prediction of how many calories are burned. Using the formula for calculating calories burned per minute,[4] in which calories burned per minute = 3.5 × MET × weight (in kg)/200, and the calories per gram of body fat values, in which burning 3,500 calories is equivalent to losing approximately 2,200 g of body fat.[24] A 70 kg recruit will burn approximately 9.8 calories per minute, equivalent to losing 6.16 g of body fat, when performing jumping jacks. Burning fat is important for recruits in efforts to attain a lean body mass, which hastens heat loss. This is because lean tissue having higher thermal conductivity than fat tissue.[25] Employing jumping jacks in PT, or even as a disciplinary method outside of PT, is important for maintaining recruits' lean body mass and their resistance to heat stress in hot environments. A previous study [26] revealed that older firefighters were more likely to gain weight and less likely to lose weight compared to younger firefighters. As for the optimal number of jumping jacks, recent recommendations[27] have identified a regimen of 50 to 100 jumping jacks performed 3 to 5 days per week in sets of 10 as beneficial, particularly for bone density, which supports the experts' intensity categorisation in this study.

Having said this, functional strength is subjective and can be influenced by age-related changes in muscle performance and preceding periods of physical inactivity. The time needed to build the strength of targeted muscles is shorter in people younger than 25 years of age compared to those 30 years of age and older. A possible explanation for this may relate to the involuntary loss of muscle mass (primarily skeletal muscle) that occurs with increasing age due to the depletion of proteins and amino acids as the primary substrate of skeletal muscle maintenance.[28] It has been proposed that decreases in testosterone may decrease muscle protein synthesis, muscle mass and strength. Although the levels of bioavailable testosterone remain consistent until men are in their 30s to 40s, after which they decline by approximately 1.2% per year,[29] muscle mass begins to decrease by approximately 3%–8% per decade after the age of 30.[30] This is exacerbated by periods of inactivity, with a rate of 1 kg of muscle mass loss observed over 10 days of physical inactivity and accompanied by a decline in strength ranging from 0.3% to 4.2% per day.[31]

Regardless of age- and activity-related considerations, muscle strength can be developed with the correct training. Although it is important to build an age-appropriate programme under a physical trainer's guidance to prevent injury, this method is not practical in the Fire and Rescue Academy of Malaysia. In this safety-critical recruitment centre, the objective is to produce functionally fit operation crews who can wear full turnout gear and an SCBA while executing rescue and firefighting functional movements regardless of age-related factors. Although recruits' range in age from their early 20s to their late 30s, they are treated equally to ensure that within 16 weeks they are physically ready for fire suppression tasks, confined-space rescues, and victim extraction from entrapment in vehicles. Examples of fire suppression tasks include pulling down a ceiling using hand tools, laying out the hose, advancing water-filled hose lines, raising, and climbing ladders, lifting and carrying heavy equipment or

victims, and conducting search and rescue in a confined area while wearing full turnout gear with an SCBA. The Jaws of Life, a hydraulic rescue tool that is used to cut through cars to open vehicles' doors and release trapped victims, may be as heavy as 18 to 25 kg. Significant functional upper body strength, dexterity and control are thus needed to manoeuvre the large device around a vehicle.

Overall, the experts prioritised exercises that concurrently target functional strength and the cardiovascular system. These exercises can be easily incorporated with limited equipment in large group settings. While PT programmes improve functional strength levels and job performance in firefighter recruits, PT is just one component of optimising physical job performance and must be employed in combination with appropriate nutrition, good hydration, and holistic physical fitness. Adequate daily dietary protein intake is important for preventing muscle mass loss and thus maintaining skeletal muscle performance. When designing the PT programme in this study, we assumed that all recruits had adequate nutrition, although internal information regarding recruits' lifestyles from personal communication and recent empirical evidence from a group of career firefighters in a developed country suggest otherwise. We additionally assumed that recruits had enough hydration and recovery, as ample time was provided for drinking during and between exercise and for sleeping.

Limitation of the Study

While the Nominal Group Technique (NGT) can be valuable for extracting information about suitable exercises for specific muscle groups, it also has limitations. The NGT typically involves a smaller group of participants with similar cultures, which may limit the diversity of perspectives and ideas. This could result in a narrower range of exercise options being considered. Although the NGT typically generates group-level recommendations, it may not fully account for individual differences, such as fitness level, injury history, or personal preferences. Consequently, the exercises identified through the NGT may not be suitable for all individuals. In addition, group-level recommendations tend to focus on traditional exercises rather than more innovative alternatives due to the structured nature of the NGT, which may discourage participants from exploring unconventional exercise options.

CONCLUSION

This study demonstrated that mNGT is an effective tool when used in an expert group to identify high-priority exercises for training firefighter recruits' functional strength. The exercises chosen through consensus were multi-joint exercises targeting agonist and antagonist skeletal muscle groups that mimicked movements of daily work life. The PT programme developed provides opportunities for common skeletal muscle groupings to be targeted simultaneously to increase cardiovascular adaptations over a shorter period. The experts' consensus on exercise type and intensity was corroborated by previous empirical evidence. Thus, this PT programme is appropriate for use in firefighter recruit programmes to standardise training procedures and promote a structured protocol that develops deployable firefighters and prevents physical injury.

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REFERENCES

1. Kerrigan D, Moss J. Firefighter Functional Fitness: The Essential Guide to Optimal Firefighter Performance and Longevity. USA: Firefighter Toolbox LLC; 2016. 313 p.
2. Feto Y, Fountaine C. General Principles of Exercise Prescription. In: Liguori G, Feito Y, Fountaine C, Roy B, editors. ACSM'S Guidelines for Exercise Testing and Prescription. 11th ed. Wolters Kluwer; 2022. p. 142–66.
3. AL Busafi M. The Importance of Physical Fitness Programs for Firefighters. J Phys Educ 2021;33(2):171–6.
4. Bushman B. Improving your aerobic fitness. In: Bushman B, editor. Complete Guide to Fitness and Health. 2nd ed. USA: American College of Sports Medicine; 2017. p. 79–100.
5. Noor Dalila Inchi Zainal Abidin. Firefighter Functional Fitness: Issues and Solution.

Kuala Lumpur; 2024.
6. Perintah Tetap Ketua Pengarah. Perlaksanaan Ujian Individual Physical Proficiency Test [Internet]. Vol. Bil 2, Fire and Rescue Department of Malaysia. 2014. p. 22. Available from: https://www.bomba.gov.my/wp-content/uploads/2021/07/ippt.pdf
7. National Fire Protection Association. NFPA code 1582: Standard on Comprehensive Occupational Medical Program for Fire Departments. US; 2021.
8. O'Connell ER, Thomas PC, Cady LD, Karwasky RJ. Energy costs of simulated stair climbing as a job-related task in fire fighting. J Occup Med. 1986;28:282–4.
9. Ainsworth B, Haskell W, Herrmann S, Meckes N, Bassett D, Tudor-Locke C, et al. 2011 Compendium of Physical Activities. Med Sci Sport Exerc [Internet]. 2011 Aug;43(8):1575–81. Available from: https://journals.lww.com/00005768-201108000-00025
10. Kollock R, Thomas J, Hale D, Sanders G, Long A, Dawes J, et al. The Effects of Firefighter Equipment and Gear on the Static and Dynamic Postural Stability of Fire Cadets. Gait Posture [Internet]. 2021 Jul;88(4):292–6. Available from: https://linkinghub.elsevier.com/retrieve/pii/S0966636221002277
11. Dunham RB. Nominal Group Technique: A Users' Guide [Internet]. 1988. Available from: https://sswm.info/sites/default/files/reference_attachments/DUNHAM 1998 Nominal Group Technique - A Users' Guide.pdf
12. FitnessHealth101. Push/Push Weight Training Program [Internet]. 2025. Available from: https://www.fitnesshealth101.com/fitness/weight-training/strength-training/pushpush-program
13. Wiggins ST, Colby S, Moret L, McElrone M, Olfert MD, Riggsbee K, et al. A modified nominal group technique (mNGT)-finding priorities in research. Am J Health Behav. 2020;44(3):345–52.
14. Ebben WP, Wurm B, Vander Zanden TL, Spadavecchia ML, Durocher JJ, Bickham CT, et al. Kinetic Analysis of Several Variations of Push-Ups. J Strength Cond Res [Internet]. 2011 Oct;25(10):2891–4. Available from: https://journals.lww.com/00124278-201110000-00031
15. Kikuchi N, Nakazato K. Low-load bench press and push-up induce similar muscle hypertrophy and strength gain. J Exerc Sci Fit [Internet]. 2017 Jun;15(1):37–42. Available from: https://linkinghub.elsevier.com/retrieve/pii/S1728869X17301028
16. Topend Sport Network. Push Up [Internet]. 2023 [cited 2023 Mar 26]. Available from: https://www.topendsports.com/testing/tests/home-pushup.htm
17. Yang J, Christophi CA, Farioli A, Baur DM, Moffatt S, Zollinger TW, et al. Association Between Push-up Exercise Capacity and Future Cardiovascular Events Among Active Adult Men. JAMA Netw open [Internet]. 2019;2(2):e188341. Available from: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6484614/
18. Fisher J, Steele J, Bruce-Low S, Smith D. Evidence-Based Resistance Training Recommendations. Med Sport [Internet]. 2011 Sep 1;15(3):147–62. Available from: http://versita.metapress.com/openurl.asp?genre=article&id=doi:10.2478/v10036-011-0025-x
19. Yi Rong Tan, Farid Wajdi Mahyuddin, Norhayati Mahyuddin. MATEC Web of Conferences. In: The analysis of fire losses and characteristics of residential fires based on investigation data in Selangor, 2012-2014. 2016.
20. Lindberg AS, Oksa J, Antti H, Malm C. Multivariate Statistical Assessment of Predictors of Firefighters' Muscular and Aerobic Work Capacity. Piacentini MF, editor. PLoS One [Internet]. 2015 Mar 16;10(3):e0118945. Available from: https://dx.plos.org/10.1371/journal.pone.0118945
21. Songsorn P, Somnarin K, Jaitan S, Kupradit A. The effect of whole-body high-intensity interval training on heart rate variability in insufficiently active adults. J Exerc Sci Fit [Internet]. 2022 Jan;20(1):48–53. Available from: https://linkinghub.elsevier.com/retrieve/pii/S1728869X21000435
22. Fang SC, Wu YL, Tsai PS. Heart Rate Variability and Risk of All-Cause Death and Cardiovascular Events in Patients With Cardiovascular Disease: A Meta-Analysis of Cohort Studies. Biol Res Nurs [Internet]. 2020 Jan 26;22(1):45–56. Available from: http://journals.sagepub.com/doi/10.1177/1099800419877442
23. Herrmann SD, Willis EA, Ainsworth BE, Barreira T V., Hastert M, Kracht CL, et al. 2024 Adult Compendium of Physical Activities: A third update of the energy costs of human activities. J Sport Heal Sci [Internet]. 2024 Jan;13(1):6–12. Available from:

https://linkinghub.elsevier.com/retrieve/pii/S2095254623001084

24. Kruskall L. Weight Management. In: Bushman B, editor. Complete Guide to Fitness and Health [Internet]. 2nd ed. USA: American College of Sports Medicine; 2017. p. 351–68. Available from: https://www.calameo.com/read/00665682252ac0fc91e3e
25. Speakman JR. Obesity and thermoregulation. Handb Clin Neurol [Internet]. 2018;156:431–43. Available from: https://linkinghub.elsevier.com/retrieve/pii/B9780444639127000266
26. Mathias KC, Wu Y, Stewart DF, Smith DL. Differences in 5-year weight change between younger and older US firefighters. BMC Public Health [Internet]. 2021 Dec 24;21(1):1215. Available from: https://bmcpublichealth.biomedcentral.com/articles/10.1186/s12889-021-11266-x
27. Witzke K, Winters-Stone K. Osteoporosis and Bone Health. In: Bushman B, editor. Complete Guide to Fitness and Health. 2nd ed. USA: American College of Sports Medicine; 2017. p. 321–38.
28. Welle S, Thornton C, Jozefowicz R, Statt M. Myofibrillar protein synthesis in young and old men. Am J Physiol Metab [Internet]. 1993 May 1;264(5):E693–8. Available from: https://www.physiology.org/doi/10.1152/ajpendo.1993.264.5.E693
29. Institute of Medicine (US) Committee on Assessing the Need for Clinical Trials of Testosterone Replacement Therapy. Testosterone and Aging [Internet]. Liverman C, Blazer D, editors. Clinical Research Direction. Washington, D.C.: National Academies Press; 2004. Available from: http://www.nap.edu/catalog/10852
30. Volpi E, Nazemi R, Fujita S. Muscle tissue changes with aging. Curr Opin Clin Nutr Metab Care [Internet]. 2004 Jul;7(4):405–10. Available from: http://journals.lww.com/00075197-200407000-00009
31. Tieland M, Trouwborst I, Clark BC. Skeletal muscle performance and ageing. J Cachexia Sarcopenia Muscle [Internet]. 2018 Feb;9(1):3–19. Available from: https://onlinelibrary.wiley.com/doi/10.1002/jcsm.12238.