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The Effectiveness of Current Fire Fighter Rapid Intervention Teams

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Final Report:

The Effectiveness of Current Fire Fighter Rapid Intervention Teams

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Main Research Findings and Fire Fighter Safety Implications

1. Fire service organizations should be aware of the limitations of a two person Rapid Intervention Team (RIT). A two person RIT team may not be able to rescue a downed or trapped fire fighter, and will not be able to rescue two or more trapped fire fighters. If a two person RIT team attempts to rescue a victim fire fighter the quality of the rescue will be compromised. The current study found that it is very difficult for two fire fighters to locate, package, maintain air supply and remove a victim fire fighter safely while maintaining effective fire ground communication.

2. During a fire attack the initial RIT team should consist of at least 2 members. When a 2 member RIT team is deployed, it should act as a Rescue Stand-By team, and develop a Rescue Action Plan. In the event that a rescue is required, the Incident Commander should immediately increase the original RIT team to 4 members. This is based on one fire fighter requiring rescue. If the rescue becomes more involved the Incident Commander will have to allocate more resources to RIT. This finding supports NFPA 1710: 5.2.4.3.2 which states that when an incident escalates, or when significant risk is present to fire fighters due to the magnitude of the incident, the Incident Commander shall upgrade the RIT to 4 fully equipped and trained fire fighters.

3. The current study has found that it is more effective to divide a RIT team into positions with specific areas of responsibility:
    a. *Team Leader* – to make decisions, order additional equipment, and to maintain a reliable communication link with Incident Command.
    b. *Air Management Position* – responsible for monitoring and maintaining the victim fire fighter(s) air supply.
    c. *Rescuers (2)* – responsible for packaging and assisting with removal of the injured fire fighter(s).

    A two person RIT team should have a team leader and an air management position. The two person team can then request additional rescuers when required.

4. Fire service organizations should consider using 1800L (45 min.) air cylinders as a minimum cylinder size for interior entry operations that are considered to be immediately dangerous to life and health (IDLH). Commonly used 1200L (30 min.) cylinders may not allow enough air supply for the victim fire fighter or the rescue team members.

5. Fire service organizations should consider adopting policies requiring fire fighters to exit the IDLH atmosphere *prior* to consuming their emergency reserve air supply (last 25% of SCBA cylinder). This is supported by NFPA 1404- *Standard for Fire Service Respiratory Protection Training*, which mandates that firefighters be out of the hazard area before their low-air alarm activates.

6. Fire Service Organizations should conduct RIT training at least annually, with a focus on both theory and practical hands-on drills as part of fire fighter job performance requirements. Current RIT teams are not as effective as they could be and this may contribute to future fire ground injuries and fatalities.

Executive Summary

In the past decade the fire service has recognized the need for policies and programs to be put in place so that they can rescue lost and trapped firefighters. Recent research has suggested that 4 fire fighters should be the minimum considered for fire fighter rescue, even though OSHA, NFPA and Worksafe guidelines currently require 2 fire fighters. Currently in British Columbia, Rapid Intervention Teams are mandated by WorkSafeBC (R 31.32), however there is some controversy regarding the effectiveness of current RIT procedures. The purpose of a Rapid Intervention Team (RIT) is to locate and rescue lost, trapped, and/or injured fire fighters at an emergency scene. The main research goal of this study was to evaluate the effectiveness of current Rapid Intervention Team protocols and then provide practical recommendations that fire departments could use to improve current RIT policies and practices.

This study set out to determine the effectiveness of a 2 person RIT team compared with a 4 person team. Results from the study demonstrated that a 2 person RIT team may not be able to rescue a downed or trapped fire fighter, and will not be able to rescue two or more trapped fire fighters. If a 2 person RIT team attempts to rescue a victim fire fighter, the quality of the rescue will be compromised. The current study found that it is very difficult for 2 fire fighters to locate, package, and remove a victim safely while maintaining and the victim's critical air supply and effective fire ground communication.

A main conclusion from this study is that when a rescue is required, the Incident Commander should immediately increase the original RIT team to 4 members. This is based on one fire fighter requiring rescue. If the rescue becomes more involved the Incident Commander will have to allocate more resources to RIT. This conclusion supports NFPA 1710: 5.2.4.3.2 which states that when an incident escalates, or when significant risk is present to fire fighters due to the magnitude of the incident, the Incident Commander shall upgrade the RIT to 4 fully equipped and trained fire fighter.

An important conclusion from this study was the need to assign individual responsibilities to each member of the RIT team. This was based on qualitative investigator observations during the RIT scenarios and from spontaneous and informal statements made by study participants. It was observed that if there was not a dedicated air management position, there were more incidents of the victim's SCBA mask being

dislodged and not replaced during extrication. If an individual was assigned the air management position, they were much more attentive to the air needs of the victim and there was a greater chance that air supply would be maintained throughout the rescue. It was also observed that when a team leader had to perform physical tasks during a rescue, their decision making was impaired and they had a harder time maintaining effective fire ground communication. These qualitative findings complemented the quantitative results from the study. These observations made it very evident that it is more effective to divide a 4 member RIT team into positions with specific areas of responsibility. A *Team Leader* is required to make decisions, order additional resources, and to maintain a reliable communication link with Incident Command. An *Air Management* position is responsible for monitoring and maintaining the victim's air supply. Two *Rescuers* are responsible for packaging and assisting with removal of the injured fire fighter. A 2 person RIT should have a team leader and an air management position, and then request additional rescuers when required. RIT teams must fit into the incident command system, and each RIT team member should have specific responsibilities in order for the team to function efficiently.

There were some very interesting observations recorded during the RIT scenarios. These qualitative observations outline some interesting RIT trends and warrant further research. It was observed that low air alarms activated during a rescue added confusion to the scenario and hampered the rescue. It was observed that career fire fighters demonstrated better situational awareness than student fire fighters during a rescue. The student fire fighters were able to rescue a victim as fast as the career fire fighters, but were much rougher with the victim which could lead to possible victim injuries.

The time required to rescue a downed fire fighter is commonly underestimated by most fire fighters. During this study an almost universal response from most subjects was that the rescue took longer than they anticipated and the rescue was much more physically demanding than they expected. In the current study the average time for a 2 person RIT team to locate, package and remove a downed fire fighter located 50 feet inside a building was 11.62 $\pm$ 1.77 minutes. Results from this study demonstrated that an initial 4 person RIT team was able to rescue 2 downed fire fighters significantly faster than an initial 2 person RIT team that was supplemented with 2 more RIT members once they reached the first victim. It took the 4 member RIT teams 16.67 $\pm$ 1.02 minutes to

rescue the 2 downed fire fighters. Under the same conditions, the RIT teams that started with 2 members and then asked for 2 more members once the initial victim was reached, took 22.03 $\pm$ 1.18 minutes.

Two common structure fire obstacles evaluated in this study were stairs and windows. The average time for a 2 person RIT team to safely bring an unconscious fire fighter up one flight of stairs was 1.66 $\pm$ 0.32 minutes. Most subjects found this short scenario to be extremely physically demanding. Lifting an unconscious fire fighter through a window is a very difficult task, and in the past fire fighters have perished because rescuers could not get the unconscious fire fighter out a window. In this study the average time for the trained 4 member RIT team to package and lift an unconscious fire fighter through a window was 4.62 $\pm$ 0.76 minutes. This time was significantly faster than the average time for the 2 person team of 6.71 + 1.05 minutes.

It is not possible to discuss RIT teams without exploring the challenges surrounding air management. If a victim fire fighter runs out of air prior to a RIT team locating them to provide a supplemental air supply, then that victim fire fighter will likely perish. A recommendation from this study is that fire service organizations should consider using 1800 litre (45 min.) air cylinders as a minimum cylinder size for interior entry operations that are considered to be immediately dangerous to life and health. Commonly used 1200L (30 min.) cylinders do not allow enough air supply for the victim fire fighter or the rescue team members.

The most important consideration for developing effective RIT teams is training. In this study all participants received RIT training just prior to the scenarios. With RIT training fresh in their minds most of the participants felt that they would have performed better with more practice. This demonstrates that in order for RIT teams to be effective and prepared for challenging rescues they must perform on-going training. A final recommendation from this study is that fire service organizations should conduct RIT training at least annually, with a focus on both theory and practical hands-on drills as part of fire fighter job performance requirements. RIT training should stress the fundamentals of search and rescue and must also focus on fire fighter safety during rescue situations.

Research Problem and Context

The purpose of a Rapid Intervention Team (RIT) is to locate and rescue lost, trapped, and injured fire fighters at an emergency scene. The research problem investigated in this study was to evaluate the effectiveness of current RIT procedures and then provide practical recommendations that fire departments can use to improve their current RIT policies and practices. The study specifically tried to determine the effectiveness of a 2 person RIT team compared to a 4 person team during various downed fire fighter scenarios. Current RIT teams staffed with only 2 fire fighters may be dangerously inadequate. The physical and psychological stresses associated with a fire fighter rescue are immense. Recent research has suggested that 4 fire fighters should be the minimum considered for fire fighter rescue, even though OSHA, NFPA and Worksafe guidelines currently require 2 fire fighters. When fire fighters are trapped or injured at an emergency scene, saving them may require more than the current rescue techniques and training. A fire fighter assigned to rescue one of their own will place themselves in extraordinarily dangerous conditions, and may work with less regard for safety than during typical fire fighting situations. For a fire fighter rescue to be successful, it is essential that fire fighters receive training in effective RIT rescue techniques.

This research is significant since there is very limited data available on the effectiveness of current RIT protocols. It is obvious that much more research is required to study the effectiveness of 3 person RIT teams and the optimal frequency of RIT training. The main objective of the research was to provide recommendations for developing more effective and efficient RIT protocols. This research was intended to increase the overall level of safety for all fire fighters who may be exposed to an environment that poses an immediate threat to life and health.

Review of Fire Fighter Rapid Intervention Teams

Introduction

There is very limited scientific research, or documented practical research, that has analyzed the effectiveness of rapid intervention teams (RIT). RIT research is important because fire fighters routinely work in dangerous situations. It is difficult to quantify the risk faced by fire fighters as there are a number of factors that may make one emergency scene more dangerous than the next. It is also difficult to determine how prepared a fire fighting crew is for work in dangerous environments. The potential health risk to fire fighters is related to a several factors such as; experience, training, staffing levels, equipment, command structure, officer decision making experience, building construction and many others.

Public education and new fire prevention regulations have resulted in a gradual decrease in the number of structure fires that a fire fighter will attend. However, new building construction material and furnishings have resulted in building fires being hotter and more toxic than in the past. New building construction, particularly pre-fabricated lightweight trusses, increases the potential for rapid building collapse. Buildings today are more air tight and contain a much higher fuel load than buildings of a generation ago. The fuel load contained in modern fires is primarily composed of synthetic materials, plastics and other hydro-carbon material. An average house fire today contains 1700 pounds of plastics capable of producing up to 20,000 British Thermal Units per pound (BTU/lb). This heat production is significantly higher than an organic fuel package contained in a typical house fire thirty years ago that was primarily composed of natural products, producing an estimated 8000 BTU/lb.

It can be concluded that structure fires today pose more of a risk to fire fighters than in the past. This problem is compounded by the fact that fire fighters today typically have limited structural fire fighting experience due to the gradual decline in structure fires. This lack of fire fighting experience is difficult to make up with training alone. Most urban fire fighters do not have the opportunity to train in real acquired structures, and therefore fire fighters today receive limited live fire training due to cost, and environmental reasons. Almost all live fire training today is conducted in fuel controlled non–combustible burn buildings that may produce a false feeling of safety for fire fighters. The protective clothing worn by fire fighters may add to a sense of security, as advances in protective clothing technology have allowed fire fighters to advance further into hot dangerous environments. New technology, such as Thermal Imaging Cameras (TICs), and advances in Self Contained Breathing Apparatus (SCBAs) may also give a fire fighter a false sense of security. This creates an increased opportunity for a fire fighter to be trapped or become disoriented within a building. This also means that when a fire fighter runs low on air they will have a greater distance to travel to exit the building. The changes in building construction, fire fighter training, technology and improved protective clothing all significantly increase the chance of fire fighters being trapped inside of a building. This fact has been recognized in the fire service and has led to the creation and implementation of Rapid Intervention Teams.

Firefighters Injuries and Deaths

There are approximately 100 fire fighter deaths and 100,000 injuries in North America every year. In April 2002, the U.S. Fire Administration published the Firefighter Fatality: Retrospective Study, which analyzed the data accumulated by the National Fire Data

Center over the previous decade. The study reported that fire fighter line-of-duty fatalities declined from 171 deaths in 1978 to 77 deaths in 1992. Since 1993, there have been more than 100 fire fighter fatalities almost every year. In the late 1970's firefighter deaths inside structure fires occurred at a rate of 1.8 deaths per 100,000 structure fires. By the late 1990's this number had risen to almost 3 deaths per 100,000, and more recently it has climbed to nearly 4 deaths per 100,000 fires (U.S. FIRE ADMINISTRATION. 2004). The Canadian Fallen Fire Fighter Foundations reports 80 fire fighter deaths in Canada in the last 10 years, 10 of them in British Columbia.

Despite the gradual decline in structure fires each year, the number of fire fighter deaths and injuries per 100,000 structure fires continues to rise. This statistic indicates that there is an increased chance of a fire fighter fatality at a structure fire compared to 20 years ago. There are various factors contributing to these deaths and injuries. Despite the advances in safety equipment and updated procedures, a fire fighter today has an increased risk of getting injured or killed at a fire than in the past.

Why the Need for Rapid Intervention

There are many documented examples of situations where effective Rapid Intervention Teams may have saved the life of a fire fighter. A good example is what occurred in Clearwater, British Columbia on March 29, 2004. The Clearwater Volunteer Fire Department was dispatched to a report of smoke coming from a restaurant. When they arrived two fire fighters entered with a charged hose line to try and locate the fire. The fire fighters were unable to locate the fire and soon made a distress call. Following the distress call, a RIT entered the front of the building to search for the two fire fighters but were unable to locate them. A second RIT entered the rear of the building and were able

to locate one of the fire fighters. One fire fighter was not located and perished in the building. The surviving fire fighter reported that they had become confused and disoriented trying to get to the back of the building. The WCB investigation report outlined a number of areas of deficiency in the training of the fire fighters and maintenance of the fire fighting equipment by the Clearwater Fire Department.

In February 2007 six fire fighters entered a house fire in Winnipeg looking for anyone left inside. It appears they were trapped on the second floor by what was likely a flashover. Two of the fire fighters were killed and four were injured. In Worchester Massachusetts (1999) six fire fighters were killed when they become lost in a burning warehouse. The incident commander had to make the difficult decision of not losing any more fire fighters looking for the lost individuals. There are several other documented cases where fire fighters have died due to ineffective rescue attempts.

Two-In/Two-Out

There is some confusion in the fire service with regard to the use of Rapid Intervention Teams, and the two-in/two out rule. The OSHA "two-in/two out" rule for fire fighters outlines the procedures for interior structural firefighting. It establishes that the employer shall ensure the at least two employees enter the immediately dangerous to life and health (IDLH) atmosphere and remain in visual or voice contact with one another at all times. If two employees have entered the IDLH atmosphere at least two employees need to be located outside the IDLH atmosphere. According to OSHA, at least one of the outside fire fighters must actively monitor the status of the inside fire fighters and may not be assigned additional duties. The second outside fire fighter may be involved in other fire ground activities, but any additional assignments for the second fire fighter must be

weighed against the potential for interference with this requirement. Both fire fighters must be able to provide immediate assistance to the two interior firefighters.

The OSHA standard applies to all workers engaged in firefighting activities. This includes municipal fire departments, volunteer fire departments, industrial fire crews, and private fire companies. The 1997 edition of NFPA 1500 includes the two-in/two-out policy required by OSHA.

National Fire Protection Association

The NFPA 2004 edition provides additional rapid intervention guidelines for career departments (1710) and volunteer fire departments (1720). NFPA 1710: 3.3.29 defines a Rapid Intervention Crew (RIC) as a dedicated crew of fire fighters who are assigned for rapid deployment to rescue lost or trapped members. NFPA 1710: 5.2.4.2.2 (8) states that an initial full alarm assignment shall provide for the establishment of an IRIC that shall consist of a minimum of two properly equipped and trained individuals. NFPA 1710: 5.2.4.3.2 states that when an incident escalates beyond an initial full alarm assignment or when significant risk is present to fire fighters due to the magnitude of the incident, the incident commander shall upgrade the IRIC to a full rapid intervention crew(s) (RIC) that consists of four fully equipped and trained fire fighters. NFPA 1407 (Draft 2008) is a new standard which specifies the basic training procedures for fire service personnel to conduct fire fighter rapid intervention operations as specified in NFPA 1710. The purpose of NFPA 1407 is to specify a training program that is designed to create a highly disciplined operational capability to rescue fire fighter(s) who become lost, injured, trapped, incapacitated, or disoriented in the course of an emergency scene or training operation.

WorkSafeBC.

In British Columbia, WorkSafeBC has taken the OSHA and NFPA guidelines into consideration and implemented the Entry into Buildings (31.23) regulation.

31.23 Entry into buildings

(1) When self-contained breathing apparatus must be used to enter a building, or similar enclosed location, the entry must be made by a team of at least 2 firefighters.
(2) Effective voice communication must be maintained between firefighters inside and outside the enclosed location.
(3) During the initial attack stages of an incident at least one firefighter must remain outside.
(4) A suitably equipped rescue team of at least 2 firefighters must be established on the scene before sending in a second entry team and not more than 10 minutes after the initial attack.
(5) The rescue team required by subsection (4) must not engage in any duties that limit their ability to make a prompt response to rescue an endangered firefighter while interior structural firefighting is being conducted.

Phoenix Study

One of the few well controlled and documented RIT studies was completed by the Phoenix Fire Department (PFD) following the death of a fire fighter in a supermarket in 2001. The PFD obtained three vacant buildings (warehouse, movie theater, bar) to conduct some standardized RIT drills. The RIT drills involved the first alarm company responding to the report of two fire fighters in trouble. One of the fire fighters is disoriented, while the other one is unconscious. The buildings were sealed from outside light and fire fighter facemasks were obscured to simulate heavy smoke conditions. The RIT teams were deployed as if it was a working structure fire. There were 200 RIT drills conducted using 1,114 PFD personnel. The RIT activities were monitored and timed, with the data being analyzed by an Arizona State University statistician.

The results from the Phoenix study show that Rapid Intervention is not very rapid.

Important RIT time statistics from this study were:

- Rescue ready state: 2.50 minutes
- Mayday to RIT entry: 3.03 minutes
- RIT contact with the downed fire fighters: 5.82 minutes
- Total time inside building, for each RI: 12.33 minutes
- Total time for rescue: 21.00 minutes

The study also concluded that there were three consistent ratios:

- It takes 12 fire fighters to rescue 1
- 1 in 5 RIT members will get into some type of trouble themselves
- A 3000 psi cylinder will provide 18.7 (+/- 30%) minutes of air

The objective and function of a RIT team is to locate and rescue lost or trapped fire fighters at an emergency scene. When fire fighters are trapped or lost, saving them may require more than just basic rescue techniques. Fire fighters assigned to rescue their fellow fire fighters are asked to place themselves in extremely dangerous and stressful conditions. For a RIT rescue to be successful, it is essential that team members receive specialized training and have practiced rescues as an effective team. Inexperienced firefighters are likely to make mistakes may delay the rescue of a fire fighter.

Methodology

This study evaluated the effectiveness of current RIT practices and procedures. The first phase of the study involved measuring response times to typical RIT scenarios. The response times of 2 versus 4 person RIT teams were determined where possible. These scenarios were conducted at the Justice Institute of B.C.'s campus in Maple Ridge, which is the primary fire fighting training facility in the province of B.C. In the second phase of the study potential improvements to RIT protocols were tested and evaluated by conducting RIT training scenarios in career fire departments. RIT trials were conducted on career fire fighters in Port Coquitlam, B.C. and Grande Prairie Alberta. These trials were designed to help identify and quantify the challenges associated with performing a fire fighter rescue. These results coupled with information from a comprehensive literature review helped to provide recommendations to improve RIT protocols.

Research design

Controlled RIT scenarios were conducted in the burn building at the JIBC Maple Ridge campus. During the RIT scenarios, times were recorded for individual tasks and the total time to complete the scenario. The time required for the RIT team to enter the building after a Mayday call was not recorded as there were be too many variables to accurately simulate this time. Average time from a Mayday call to RIT entry was estimated in the Phoenix study to be 3:03 min. Student fire fighters with breathing apparatus (1200L cylinders) were used as the downed fire fighters needing rescue. During pilot trials it was determined that live victims provided very realistic rescue scenarios. When a dummy was used, the RIT team would drag the dummy with little concern for the victim's safety and no regard for maintaining victim air supply. When a fire fighter was used as a victim, the

RIT team had to be very aware of victim safety and maintain a good air supply. Scott face piece smoke simulating shields (dark) were used on all RIT scenarios to consistently simulate heavy smoke conditions. All fire fighters received RIT training the day before, or the day of, the scenarios. The RIT training included proper search, packaging and dragging techniques. Fire fighting students and career fire fighters received the same RIT training before the scenarios.

Subjects

The initial phase of the study utilized 80 subjects that volunteered to be monitored during the RIT scenarios. The average age of this subject group was 25 years. The subjects were comprised of students that were taking the JIBC Career Fire Fighter Pre-Employment program. In the second phase of the study, 80 career firefighters from Port Coquitlam, B.C. and Grande Prairie Alberta volunteered to be monitored during the RIT scenarios that were part of their normal fire fighter training program. The average age of the career subject group was 37 years.

Methods
The following is a description of each RIT scenario completed.

Two person RIT scenario with the victim 10 feet off a 50 foot hoseline

- RIT team is tasked to locate, package and remove a victim located 10 feet away from the nozzle of a 1 ¾ inch hoseline that is 50 feet inside a building.
- The victim is a fire fighter wearing a breathing apparatus with their pass device sounding. The victim is directed to stay motionless and not assist the RIT team.
- The RIT team used a face piece smoke simulating shield to consistently simulate heavy smoke conditions.
- The RIT team was directed to follow the downed fire fighter's hoseline into the building and then quickly, and safely, remove the downed firefighter through the door that they entered the building.
- The times recorded were: the time to locate the victim; the time to package the victim; and the time to remove the victim from the building (Appendix, Table 1).
- The time started when the RIT team entered the building. The scenario was completed by 16 teams of fire fighting students in the JIBC Pre-Employment Program. The scenario was also completed by 16 teams of career fire fighters in Port Coquitlam.
- Initial pilot studies determined that there was no significant difference between 2 and 4 person RIT teams performing this scenario. This was attributed to a 2 person team being physically capable of locating, packaging and removing a victim 50 ft inside a building. In some pilot trials the 4 person RIT team was actually slower than a 2 person team as they were hampered by each others movements.

Four person RIT scenario with two victims 100 feet inside a building

- A four person RIT team is tasked to locate, package and remove two victims 100 feet inside of a building.
- One victim is located at the nozzle of a 100 foot 1 ¾ inch hoseline and the other victim is located 10 feet away from the nozzle. Both fire fighters have pass devices sounding and the victim that is 10 feet away from the hoseline has a low air alarm sounding.
- The victims are fire fighters wearing breathing apparatus and are directed to stay motionless and not assist the RIT team.
- The RIT team used a face piece smoke simulating shields to consistently simulate heavy smoke conditions.
- The RIT team was directed to follow the hoseline of the downed fire fighters into the building and then quickly, and safely, remove the downed fire fighters through the door that they entered the building.
- The times recorded were: the time to locate each victim; the time to package the victims; and the time to remove both victims from the building.
- One scenario was conducted by sending the 4 person RIT team into the building as a unit. The other scenario was conducted by sending in a 2 person RIT team that would request an additional two members once they located the first victim.
- These scenarios were conducted using career fire fighters that had just received RIT training. There were twelve, 4 person RIT teams. Six teams started the scenario by

sending in a four person RIT team as a unit, while the other six teams sent in 2 fire fighters initially and then requested 2 more RIT team members when they found the downed victims (Appendix, Table 2).

Two person RIT scenario up one flight of stairs

- The two person RIT team was tasked to safely bring an unconscious fire fighter up one flight of stairs (14 steps, 8 inch height for each step). Appendix, Table 3.
- The victim fire fighter was wearing breathing apparatus and was directed to stay motionless and not assist the RIT team.
- The RIT team used face piece smoke simulating shields to consistently simulate heavy smoke conditions.
- These scenarios were conducted using career fire fighters that had just received RIT training. There were 20-two person RIT teams that completed the stair scenario.

Window Rescue scenario by four and two person RIT teams

- A four person RIT team was tasked to package and remove a downed fire fighter through a window.
- A two person RIT team was also tasked to remove a downed fire fighter through a window in the same conditions.
- The victim fire fighter was wearing breathing apparatus and was directed to stay motionless and not assist the RIT team.
- In each drill there were two fire fighters on the other side of the window to receive the victim and help them through the window.
- For safety reasons visibility was not obscured for this drill.
- The window was 3 feet by 4 feet and located 42 inches off the floor. There was no glass in the window and the window was wood frame with flush edges.
- The time recorded for this drill was the time to remove the victim through the window once they were packaged (Appendix, Table 3).
- Prior to the scenario the RIT teams received training on proper window extrication techniques.
- These scenarios were conducted using career fire fighters. There were 10-four person RIT teams, and 10-two person RIT teams that completed the window scenario.

Dependent measures

Time was the dependent measure in each RIT scenario. The times were recorded for individual tasks within the RIT scenario and the total time to complete the scenario. The times recorded were: the time to locate the victim; the time to package the victim; and the time to remove the victim from the building. The time to remove the victim through a window once they were packaged was recorded in the window scenario. The time to bring an unconscious firefighter up one flight of stairs was recorded in the stair scenario.

Data analysis

The average time, and the standard deviation for the time to complete each portion of the RIT scenario were computed. A t-test that used two-samples assuming unequal variances was used to determine if there was a significant difference between the time to complete each RIT scenario under the different conditions. A difference in a scenario was determined to be statistically significant when $p \leq 0.05$.

Research Findings

The average time for the 2 member RIT teams (n = 32) to locate, package and remove a victim located 10 feet away from the nozzle of hoseline that was 50 feet inside a building was 11.62 $\pm$ 1.77 minutes (Appendix, Table 1).

It took the 4 member RIT teams (n = 6) 16.67 $\pm$ 1.02 minutes to locate, package and remove two victims 100 feet inside of a building (Table 2). Under the same conditions, the RIT teams (n = 6) that started with 2 members and then asked for 2 more members once the initial victim was reached, took 22.03 $\pm$ 1.18 minutes to remove the two victims. The initial 4 member RIT teams thus rescued the 2 downed fire fighters 5.36 minutes faster than the 2 person RIT teams that initiated the rescue and then requested 2 more members to assist. The initial 4 member RIT team was significantly faster ($p = 3.76 \times 10^{-6}$) than the initial 2 member RIT team that was supplemented with 2 more members.

The average time for a 2 member RIT team (n = 20) to safely bring an unconscious fire fighter up one flight of 14 stairs was 1.66 $\pm$ 0.32 minutes (Table 3). The average time for a 4 member RIT team to package and lift an unconscious fire fighter through a window was 4.62 $\pm$ 0.76 minutes (Table 4). This time was significantly faster ($p = 5.06 \times 10^{-5}$) than the average time for the 2 person team of 6.71 + 1.05 minutes.

Discussion

In the past decade the fire service has recognized the need for policies and programs to be put in place so that they can rescue lost and trapped fire fighters. Currently in British Columbia, Rapid Intervention Teams are mandated by WorkSafeBC (R 31.32), however there is some controversy regarding the effectiveness of current RIT procedures. The main reason why there are controversies regarding RIT teams is the lack of experience from RIT training and RIT emergency situations. It is not often that a fire fighter is trapped or lost at an emergency scene, but when it happens it becomes a high priority and a stressful situation. When fire departments critique fire fighter rescue emergencies, the main reasons cited for a delayed rescue is the lack of rescue personnel, lack of RIT training and poor communication during the incident.

Most fire fighters have the unrealistic sense that if another fire fighter needs rescue, they and other fire fighters will quickly come to the aid of the downed fire fighter and drag them to safety. The reality is that a fire fighter rescue requires time, planning and resources. A fire fighter rescue will typically be a very stressful, dangerous situation where a bad decision, or delayed response, may result in the death of the fire fighter being rescued or even the rescuer.

The main purpose of this research was to outline the limitations of a two person RIT team. The results from this study and others indicate that a 2 person RIT team may not be able to rescue a downed or trapped fire fighter, and will not be able to rescue two or more trapped fire fighters. If a 2 person RIT team attempts to rescue a fire fighter the quality of the rescue may be compromised. The current study found that it is very

difficult for 2 fire fighters to locate, package, and remove a victim safely while maintaining and the victim's critical air supply and effective fire ground communication.

When RIT teams were initially mandated at structure fires more than a decade ago, many fire officers felt that they did not have adequate personnel to have 2 RIT fire fighters standing around and not helping with fire suppression activities. Many fire officers still have that opinion today. In hazardous material incidents almost all fire officers would agree that they would never send two fire fighters into a hot zone without two fully equipped and trained fire fighters dressed and prepared to enter the hot zone if anything should happen to the initial response team. In many situations, the interior of a structure fire is potentially more dangerous than a Hazmat incident. The potential for building collapse or floor failure also make the rescue in a structure fire much more difficult than a rescue in a Hazmat incident. It is therefore difficult to understand why standby rescue teams are so well accepted for Hazmat incidents and have not been as well accepted during structure fires. The reluctance to implement RIT teams at structure fires may be partially due to the traditional attitude of doing whatever it takes to put the fire out. Fire officers must understand that the most valuable items in the building are people, and in many cases the fire fighters are the only people inside the building.

RIT team members should be trained individuals that are capable of rescuing a fellow fire fighter in a dangerous situation. The common past practice of sending two less experienced fire fighters to a door to act as a RIT team is unacceptable. A RIT team at an emergency scene must be very proactive in preparing for a potential rescue. When a 2 member RIT team is deployed, they should act as a Rescue Stand-By team, and develop a Rescue Action Plan. The RIT team should complete a 360 of the building and note

secondary means of egress and other potential hazards. The RIT team should set up a tool staging area with any equipment they feel may be needed in a rescue. If deemed appropriate, the RIT team may set up a ladder to give the interior fire fighters another means of leaving the building. The RIT team should have their own status board and note which fire fighters have entered the building, when they entered the building, and what their approximate location in the building is. In the event that an incident escalates or a rescue is required, the Incident Commander should immediately increase the original RIT team to four members. This is based on one fire fighter requiring rescue. If the rescue becomes more involved, incident command will have to allocate more resources to RIT.

It would be very controversial, and not very practical, to say that all fire departments should deploy a 4 person RIT team at all structure fires. Smaller fire departments have a hard time justifying a 2 person RIT team and argue that they do not have the adequate personnel to deploy a 4 person RIT team. Smaller fire departments should understand the limitations of only having a 2 person RIT team and adjust their strategies and tactics accordingly. Fire departments must realize that the NFPA 1710: 5.2.4.3.2 standard requires that when an incident escalates, or when significant risk is present to fire fighters due to the magnitude of the incident, the Incident Commander shall upgrade the RIT to four fully equipped and trained fire fighters. This standard is based on previous research and is supported by the findings of this study.

Results from this study have demonstrated that an initial 4 person RIT team was able to rescue 2 downed fire fighters significantly faster than an initial 2 person RIT team that was supplemented with 2 more RIT members once they reached the first victim. It took the 4 member RIT teams 16.67 $\pm$ 1.02 minutes to rescue the 2 downed fire fighters.

Under the same conditions, the RIT teams that started with 2 members and then asked for 2 more members once the initial victim was reached, took 22.03 $\pm$ 1.18 minutes. The initial 4 member RIT teams thus rescued the 2 downed fire fighters 5.36 minutes faster than the 2 person RIT teams that initiated the rescue and then requested 2 more members to assist. This 5.36 minute rescue time difference seemed to be due to a more coordinated rescue effort and better decisions made by the 4 person RIT team leader. When all 4 RIT members entered the building at the same time, the team leader was able to focus on the overall rescue and assign tasks accordingly. The team leader was also able to effectively communicate with the incident commander. When a team leader entered as part of a 2 person RIT team, they were required to do more physical work initially in locating and packaging the downed fire fighters. These additional tasks performed by the team leader appeared to impair their decision making process and also interrupt effective communication. The decisions of the team leader are a critical part of any rescue process. A 4 member RIT team allows the team leader a chance to assess the situation and make the appropriate decisions needed for an effective rescue. With a 2 person RIT team the team leader will be required to do more physical work, which may impair their decision making process.

An important conclusion from this study was the need to assign individual positions with specific areas of responsibility to a RIT team. This was not an initial goal of the study but became very evident after observing several scenarios. It was observed that it is more effective to divide a 4 member RIT team into positions with specific areas of responsibility. A *Team Leader* is required to make decisions, order additional equipment, and to maintain reliable communication link with Incident Command. An *Air*

Management position is responsible for monitoring and maintaining the victim's air supply. Two *Rescuers* are responsible for packaging and assisting with removal of the injured fire fighter. A 2 person RIT should have a leader, an air management position, and then request additional rescuers when required. During scenarios it was observed that when RIT teams did not have a dedicated air management position, there were more incidents of SCBA masks getting dislodged and not replaced. If an individual was assigned the air management position, they were much more attentive to the air needs of the victim and there was a greater chance that the air supply would be maintained throughout the rescue. RIT teams must be able to fit into the incident command system, and each RIT team member should have specific responsibilities in order for the team to function efficiently.

The time required to rescue a downed fire fighter is commonly underestimated. During this study a common response from most subjects was that the rescue took longer than they anticipated and the rescue was much more physically demanding than they expected. In the current study the average time for a 2 person RIT team to locate, package and remove a downed fire fighter located 50 feet inside a building was 11.62 $\pm$ 1.77 minutes. This may seem to be a relatively quick rescue, but it should be noted that the time was started as soon as the RIT team entered the building and not when the Mayday was first called. There were no obstructions to interfere with the rescue, and the downed fire fighter was located 10 feet away from the hoseline with a pass device sounding. All RIT teams had just received rescue training. Therefore in almost ideal conditions it still took a 2 member RIT team 12 minutes to locate, package and drag a downed fire fighter 50 feet. It is almost certain that any fire fighter rescue situation would involve debris,

furniture or obstructions in an unfamiliar environment. The current study was conducted on polished concrete floors that allowed for easy dragging of victims. Carpet, hardwood and other floor surfaces will add resistance to the fire fighter being dragged, and will slow down the overall rescue time and make the rescue even more physically demanding. Almost all fire fighter rescue situations will be hampered by obstacles such as doors, corners, furniture and other debris that will add to the time required to rescue a downed fire fighter. The current study used participants that had just received RIT training, and they were aware of exactly what their rescue task involved in a controlled environment. In a real fire fighter rescue situation there will be an increased opportunity for delays and the rescue times will typically be longer due to unforeseen obstacles.

Two common obstacles evaluated in this study were stairs and windows. A reasonable portion of fire fighter rescues will involve bringing the victim up or down a flight of stairs. It is very physically demanding to drag a fire fighter up or down a flight of stairs. The limited space in a stairway may dictate that only 2 rescuers can lift or drag the victim at one time. In the current study the average time for a 2 person RIT team to safely bring an unconscious fire fighter up one flight of stairs was 1.66 ± 0.32 minutes (Table 3). Most subjects found this short scenario to be extremely physically demanding. While 1 minute and 40 seconds may seem like a reasonable time to bring a fire fighter up one flight of stairs, it should be noted that these were rested fire fighters that only had to bring a victim up one flight of 14 stairs. If stairs are involved in a fire fighter rescue, a team leader should consider resting the 2 rescuers that bring the victim up a flight of stairs. This could be accomplished by requesting 2 more rescuers to take over at the top of the stairs to help remove the victim the rest of the way out of the building.

There are emergency fire ground situations when a fire fighter may need to be lifted through a window, because the original entrance cannot be used due to fire or building collapse. Lifting an unconscious fire fighter through a window is a very difficult task, and in the past fire fighters have perished because rescuers could not get the unconscious fire fighter out a window. The current study evaluated the time required for both a 4 and 2 person RIT team to package and remove a downed fire fighter through a 3 foot by 4 foot window located 42 inches off the floor. The average time for the trained 4 member RIT team to package and lift the unconscious fire fighter through the window was 4.62 $\pm$ 0.76 minutes (Table 4). This time was significantly faster than the average time for the 2 person team of 6.71 + 1.05 minutes. Two of the 2 person RIT teams were unable to lift the unconscious fire fighter through the window and were not given a time. These results indicate that a 4 person RIT team is required to safely lift an unconscious fire fighter through a window. A 2 person RIT team may be able to accomplish the task, but it will be slow and they may not be able to safely lift the unconscious fire fighter through the window. These results also indicate that it will take trained rescuers approximately five minutes to package a downed fire fighter and safely lift them through a window. It can be concluded from these results that rescuing a fire fighter through a window is a time consuming and labour intensive task.

It is not possible to discuss RIT teams without exploring the challenges surrounding air management. If a fire fighter runs out of air prior to a RIT team locating them to provide supplemental air, then that fire fighter will likely perish. The smoke produced by today's fires is a deadly combination of carbon monoxide and hydrogen cyanide that has the potential to kill a human in as little as one breath. Not only is modern

fire smoke significantly more toxic than the smoke of yesterday, but there is also more of it, due to the abundance of synthetic material found in current buildings. Although most fire fighters now realize the tremendous dangers of modern fire smoke, the North American fire service has been slow to change SCBA practices and develop air management guidelines to protect these fire fighters.

In recent years the fire service has made great advances in protecting the lives of fire fighters by recognizing that RIT teams are not only essential but are now mandated in many jurisdictions. The fact is that without good air management practices, the best equipped and most efficient RIT teams will be ineffective. It is crucial when a fire fighter enters a building that they have a sufficient amount of air to sustain their life until a RIT team arrives, should he or she be confronted with an emergency such as a collapse, entrapment, electrical shock or extreme temperature. According to N.F.P.A. Firefighter Fatality Reports between 1996 and 2003, there were 103 deaths directly attributed to asphyxiation. These numbers do not include the direct contribution that "running out of air" played in deaths attributed to factors, such as thermal insult, collapse or cardiac arrest. Asphyxiation accounts for 63% of fire fighter fatalities on the fire ground.

It is important to have realistic RIT expectations. There have been numerous studies, including this one, that have attempted to quantify exactly how long it will take a RIT team to locate, assess and provide supplemental air to a lost or injured fire fighter. The Seattle Fire Department has shown that in perfect condition training scenarios, the ability for a RIT to consistently locate and provide air to a downed fire fighter takes 10-15 minutes (Gagliano *et al*. 2008). As previously mentioned, the Phoenix RIT study concluded that it takes an average of 8.85 minutes to reach the victim fire fighter's side

once the Mayday is called. Average time from Mayday to victim fire fighter removal was 21 minutes. In the current study the average time for a 2 person RIT team to locate, package and remove a downed fire fighter located 50 feet inside a building was approximately 12 minutes. These results show that rapid intervention is in fact, not rapid. If the victim fire fighter does not have sufficient reserve air to survive until a RIT locates and provides supplemental air, the rescue will likely be unsuccessful. It is time consuming for a RIT team to locate, assess and give cylinder air to a trapped or injured fire fighter. If the victim fire fighter does not have the necessary 25% reserve air as a minimum, there is little chance a rescue will be successful. Fire service organizations should consider adopting policies requiring fire fighters to exit IDLH atmospheres *prior* to members beginning to consume their emergency reserve air-supply (last 25% of SCBA cylinder). NFPA 1404: 5.1.4(2) states that fire fighters must be out of the IDLH atmosphere *before* their low-air warning alarm activates. If a fire fighter's low-air warning alarm activates while they are inside the hazardous environment, then this is an immediate action item for the individual and team.

The rate at which a fire fighter will consume their SCBA air depends on a number of factors. Air consumption is high when fire fighters perform strenuous work in full Personal Protective clothing and Equipment (PPE). Other factors that cause increased air consumption include elevated body core temperature, dehydration, physical fatigue and emotional stress. Taken together, these factors will result in increased respiratory demand over the course of the fire fighter's work cycle. Respiratory demands may vary from a resting rate of 40 litres per minute (LPM) to a maximum rate of over 400 LPM (Safety Equipment America, 2002).

While manufacturer information provided with SCBA cylinders indicate that 300 litres (L) will provide up to six minutes of air, the reality is that a hardworking, physically stressed fire fighter can easily consume 300L of air in less than three minutes (Gagliano *et al*. 2008). Three minutes will barely cover the time it takes a RIT team to prepare and enter the building. The 300 litres of air left when a 30 minute (1200L) cylinder alarms simply does not allow enough time to rescue a fire fighter should anything unexpected happen during egress from the structure. The 30 minute SCBA cylinder has been the standard for North American fire fighters since SCBAs where widely implemented. It is common knowledge among fire fighters that a 30 minute SCBA will last approximately 12-18 minutes during fire suppression activities, but the cylinder is still referred to as a 30-minute cylinder. It is more appropriate to refer to SCBA cylinders in terms of volume of air and not time. A 30 min cylinder contains 1200 L of air, a 45-min cylinder contains 1800L, while a one-hour cylinder holds 2400L of compressed air.

Fire service organizations should consider using a minimum 1800L (45 min) air cylinder when entering a structure fire. Commonly used 1200L (30 min) cylinders may not allow enough air supply for the victim fire fighter or the rescue members. An 1800L cylinder provides 1350L for suppression or rescue activities, while still leaving 450L as an emergency reserve. Another possible solution to provide more air on the fire ground for both operations and as emergency reserve is to use 2400L cylinders. This option provides 1800L for operations and exit, while still leaving 600L as an emergency reserve. While using a 2400L cylinder seems like the obvious option, it is not without controversy. Although many Hazmat and confined space entry teams have been using 2400L cylinders for years, there are significant drawbacks in terms of weight and size,

causing some to question these cylinders as an appropriate choice for regular fire ground use. While there are differences depending on manufacturer and construction materials, an average 1200L cylinder will weigh approximately 8 lbs with an 1800L cylinder weighing 11 lbs and a 2400L cylinder weighing 13 lbs. The heavier 2400L cylinder will provide more air for the fire fighter but will come at the cost of increasing energy expenditure to carry the added weight. The 2400L cylinder seems to be the most appropriate choice for RIT members. During any rescue attempt air supply will be critical in ensuring the safety of the RIT members and victim. Many fire departments have acknowledged this and currently use 2400L RIT air cylinders.

During this study 1200L cylinders were used for approximately forty percent of the scenarios. During these scenarios it was common for the 1200L cylinders to activate the low air alarm between 10 and 15 minutes into the rescue. It was observed in this study that an activated low air alarm during a rescue will quickly change the priorities of the rescue, create added psychological stress, and may ultimately delay the rescue.

A common observation during the current study was that fire fighters initially thought that they were trained enough to perform a fire fighter rescue. Following the RIT scenarios almost every fire fighter commented on how they benefited from the training and that the rescue work was more physically demanding than they anticipated. When multiple scenarios were performed with the same fire fighters, it was evident that their speed and skill was improving with each scenario. An interesting observation was the difference in the performance between the student and career fire fighters. The student fire fighters were on average slightly faster than the career fire fighters during the scenario when the 2 person RIT team was tasked to locate, package and remove a victim

50 feet inside a building. The student fire fighters were trained in RIT techniques and may have had a slightly higher fitness level compared to the career fire fighters. The greatest difference observed between the career fire fighters and students was general safety awareness. When there were decisions to be made affecting the outcome of the rescue, the more experienced fire fighters took the time to act and intervene in order to ensure that the victim fire fighter was successfully rescued. The career fire fighters typically demonstrated better situational awareness and were more concerned about the safety of themselves and the victim during the scenarios. The student fire fighters focused more on just getting the victim out, and had less regard for the safety of the victim and themselves. During the removal of the downed fire fighter the student fire fighters typically handled the victim in a rough manner and were more likely to injure the victim during extrication.

The most important consideration for developing effective RIT teams is training. In order for RIT teams to be effective and prepared for challenging rescues they must perform on-going training. A final recommendation from this study is that fire service organizations should conduct RIT training at least annually, with a focus on both theory and practical hands-on drills as part of fire fighter job performance requirements. RIT training should stress the fundamentals of search and rescue. RIT training must also focus on fire behavior, building construction, air management and fire fighter safety during rescue situations. Fire fighters will typically have less regard for their own safety when intent on rescuing a fellow fire fighter. RIT training should also include self-rescue. During their career, fire fighters will spend a considerable amount of time training to rescue other people, but will spend very little time learning how to rescue themselves, if

they become trapped. RIT training must also outline the criteria for calling a Mayday. The majority of fire fighters are hesitant to call a Mayday if they are lost or trapped. By the time they do realize they are in serious trouble, it may be too late.

All fire service members should receive training that outline RIT policies and procedures for that organization. Not all fire fighters and officers will be assigned to a RIT, but they all must understand how RIT will be deployed in an emergency situation and what they will need to do to make the rescue successful. RIT team members need to be well-trained, physically and mentally fit individuals that can perform difficult rescues under extreme conditions. The RIT team will require a team leader that is capable of making some critical tactical decisions that may mean the difference between the life and death of a fire fighter. They must base their tactical decisions on sound training and experience and maintain their focus on locating, assessing, and extricating their fellow fire fighters.

The fire service continues to evolve and advance in order to meet the demands of a continually changing operating environment. Many of these advances made in recent years would not have been possible without the help of technology. Technology has the potential to make fire fighting safer. New SCBAs, digital pump panels, thermal imaging cameras (TIC's), P.A.S.S. alarms, radios and atmospheric monitoring devices are examples of new technologies that have made the fire ground a safer place to work. More recently the fire service has seen computer programs to assist with fire ground accountability and air management. There are now triangulation devices to assist RIT members in locating lost or trapped fire fighters. If used correctly these technologies will make the fire ground safer; however, there are dangers in relying excessively on

technology. These technologies can compete for the attention of fire fighters, and result in reduced situational awareness that can place the fire fighter in a dangerous situation. Recent statistics suggest that new technology is not reducing the incidence of fire ground deaths and injuries. There is no technology that will replace sound fire ground principals, regular training and fire ground experience. During this study we noticed a correlation between experience and situational awareness. Inexperienced fire fighters were less aware of their surroundings and were more likely to put themselves in a dangerous situation compared with experienced fire fighters.

Implication for future research/projects on fire fighter health and safety

There is very limited data available on the effectiveness of current RIT protocols, including supplied air systems and rescue tools. The objective of this research was to provide some general recommendations for developing more effective and efficient RIT protocols, and to outline the limitations of a 2 person RIT team. Future research must expand on these general recommendations and study the effectiveness of specific rescue techniques and tools. Future RIT research should look at the effectiveness of 3 and 5 person RIT teams and the optimal frequency for RIT training. Future RIT research will increase the safety of all fire fighters who may be exposed to dangerous situations.

Immediate and long-term benefits of the results

The immediate benefit of the research results will be reduced rescue times for trapped fire fighters. The recommendations from the study can be used to educate fire fighters throughout the province in effective RIT procedures. The research results provide information on the effectiveness of current RIT protocols and provide valuable information for policymakers who must decide on the appropriate allocation of resources

at emergency scenes. The long-term benefit of the results is that it establishes some sound recommendations on effective RIT techniques and protocols that may be modified with future technology and research findings.

Implications for future training and education projects

The recommendations from this study should be tested and evaluated by conducting RIT training drills in both career and volunteer fire departments throughout the province.

Relevant user groups for the research results

The relevant user groups for the research results are all fire departments in North America. In British Columbia the research results and recommendations are useful to all fire department personal. The key user groups to benefit from the information are B.C. Fire Chiefs and Training Officers. Fire Chiefs are in the position to influence policies that will produce more effective RIT teams. Fire Chiefs and commanding officers are the key policymakers who must decide on the appropriate allocation of resources at emergency scenes. Training officers are in the position to ensure that fire fighters receive appropriate RIT training and education.

Dissemination/knowledge transfer

The results from this research will be disseminated through fire fighter journal articles. Information from the study will also be made available to B.C. Fire Departments through the Justice Institute of B.C. and through the WorkSafeBC program. The Justice Institute of B.C. has already incorporated the RIT recommendations from this study in their current RIT training program that is offered throughout the province. Two RIT training days has also been implemented in the Justice Institute Career Fire Fighter Pre-Employment Program. Research findings will hopefully be presented to the B.C. Fire Chiefs and Training Officers at the appropriate conferences in 2010.

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APPENDIX

Table 1. Time (minutes) for the 2 member RIT teams (n = 32) to locate, package and remove a victim located 10 feet away from the nozzle of a hoseline that was 50 feet inside of a building. Teams 1 to 16 were experienced fire fighters, teams 17 to 32 were fire fighting students.

Trial	ReachVic	Package	Extricate	Total Time
1	3.50min	5.50	5.63	14.63min
2	3.07	6.26	7.34	16.67
3	2.97	5.96	3.98	12.91
4	2.83	3.42	3.75	10.00
5	2.83	5.35	3.57	11.75
6	2.73	5.27	6.50	14.50
7	2.95	4.37	3.76	11.08
8	3.17	4.58	2.68	10.43
9	2.67	4.50	2.83	10.00
10	1.97	4.95	2.75	9.67
11	2.25	10.55	3.80	16.60
12	2.25	5.17	3.58	11.00
13	2.68	5.07	5.85	13.60
14	2.80	4.70	5.41	12.91
15	2.50	6.00	2.00	10.50
16	2.67	4.83	3.75	11.25
Average	**2.74**	**5.41**	**4.20**	**12.34min**
STD	0.38	1.54	1.51	2.30
17	2.42	6.58	3.00	12.00min
18	2.08	5.92	3.42	11.42
19	1.50	6.25	2.25	10.00
20	1.58	5.67	3.00	10.25
21	1.83	5.84	2.50	10.17
22	1.92	5.99	2.42	10.33
23	2.17	6.00	3.83	12.00
24	1.92	5.75	3.50	11.17
25	2.17	6.25	1.91	10.33
26	1.50	5.50	5.00	12.00
27	1.50	6.00	2.83	10.33
28	1.58	5.42	5.50	12.50
29	1.67	5.83	2.50	10.00
30	1.75	6.25	3.00	11.00
31	1.50	6.00	2.83	10.33
32	1.75	5.58	3.17	10.50
Average	**1.80**	**5.93**	**3.17**	**10.90min**
STD	0.29	0.31	0.95	0.84
Total				
Average	**2.13**	**5.75**	**3.70**	**11.62min**
STD	0.61	0.62	1.43	1.77

Table 2. The time (minutes) it took the 4 member RIT teams (n = 12) to locate, package and remove two victims 100 feet inside of a building. One victim was located at the nozzle of the 100 foot hoseline and the other victim was located 10 feet away from the nozzle. In trials 1 to 6 the RIT teams started with 2 members and then asked for 2 more members once the initial victim was reached. In trials 7 to 12 the RIT teams started with 4 members and could not request any other help.

2 then 2				
Trial	**ReachVic**	**Package**	**Extricate**	**Total Time**
1	5.75min	7.75	8.00	21.50min
2	7.00	6.00	9.50	22.50
3	5.00	5.25	9.75	20.00
4	7.00	8.00	7.00	22.00
5	7.50	7.00	8.33	22.83
6	8.00	6.33	9.00	23.33
Avg	**6.71**	**6.72**	**8.60**	**22.03min**
STD	1.12	1.06	1.03	1.18
4 at start				
Trial	**ReachVic**	**Package**	**Extricate**	**Total Time**
7	6.00min	5.00	6.00	17.00min
8	6.33	5.17	6.00	17.50
9	7.00	5.00	4.00	16.00
10	6.50	5.00	3.50	15.00
11	6.50	6.00	5.25	17.75
12	5.25	6.00	5.50	16.75
Avg	**6.26**	**5.36**	**5.04**	**16.67min**
STD	0.59	0.50	1.05	1.02

Table 3. The time (minutes) for a 2 member RIT team (n = 20) to safely bring an unconscious fire fighter up one flight of 14 stairs.

Trial	Time (min)
1	1.70
2	1.20
3	1.60
4	1.60
5	2.25
6	1.33
7	1.62
8	0.98
9	1.55
10	1.95
11	1.70
12	1.63
13	2.05
14	1.78
15	1.63
16	1.72
17	1.23
18	1.58
19	2.07
20	2.10
Avg	**1.66min**
STD	0.27

Table 4. The time (minutes) for a 2 member (n = 10) and 4 member (n = 10) RIT team to package and lift an unconscious fire fighter through a window. The window was 3 feet by 4 feet and located 42 inches off the floor. There were two, 2 man RIT teams that were unable to lift the unconscious fire fighter through the window.

2 Man	**Time (min) to remove victim**		**4 Man**	**Time (min) to remove victim**
Trial			**Trial**	
1	6.23		**1**	4.75
2	5.90		**2**	4.58
3	6.42		**3**	5.42
4	5.67		**4**	5.33
5	6.13		**5**	4.83
6	6.08		**6**	2.67
7	6.72		**7**	4.37
8	7.58		**8**	4.75
9	9.17		**9**	4.82
10	7.20		**10**	4.67
Average	**6.71min**		**Average**	**4.62min**
STD	1.05		**STD**	0.76

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