A retrospective evaluation of physical fitness maintenance in members of a southeastern US city professional firefighting department

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Abstract: The purpose of this study was to retrospectively assess and track the annual physical fitness performance of the members of a professional firefighting department. As part of the annual health and fitness testing (data from 2002–2017), 153 firefighters had their physical fitness evaluated using standardised and recommended protocols published by the International Association of Fire Fighters. Handgrip strength performance exhibited a significant decline from baseline ($p < .05$). Static arm pull and static leg pull performance as well as flexibility were slightly improved and largely able to be maintained throughout the length of the study ($p > .05$) until the final years ($p < .05$). Neither push-up nor plank hold performance significantly changed from baseline ($p > .05$). Based on these findings, the proposed 30-minute exercise requirement does not appear to provide a stimulus to offset declines in all fitness variables.

Keywords: firefighting; physical fitness; strength and conditioning; first responder; health-related fitness; field-testing.

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1 Introduction

Firefighting is an occupation requiring high levels of physical skill, physical fitness, and conditioning. These demands put firefighters at high risk for musculoskeletal injuries. The National Fire Protection Association (NFPA) regularly monitors injury rates based on type and location of injury to the firefighters. Campbell et al. (2019) published the data from the most recently available 2018 survey and reported that an estimated 58,250 firefighter injuries occurred during the prior year, with 39% of these injuries occurring on the fire ground. Of that 39%, the leading cause of injury was due to muscular strain, or ligament/connective tissue sprain (38%), followed closely by injuries due to overexertion (28%). There are likely multiple factors that have a role in the overexertion experienced by these firefighters, which can likely be mitigated by maintaining or improving physical fitness levels.

The personal protective equipment (PPE) and related turnout gear worn by firefighters is vital to their safety, yet, it also creates a considerable challenge with regard to preventing overexertion. When wearing turnout gear, the symptoms of heat stress and muscular fatigue are substantially elevated (Clark et al., 2002; Davis et al., 1982). The risk of thermoregulatory dangers increases due to the turnout gear's heavy layers, which can decrease water vapour permeability and prevent body heat dissipation through evaporation (Marcora et al., 2009), leading to an average rise in core temperature between 0.036–0.048ºC per minute of firefighting activity (Horn et al., 2013). Substantial increases in both heart rate and oxygen consumption (VO_2) also occurred when firefighters, in full turnout uniform and equipment (39.3 kg), completed a stair-climbing simulation exercise (60 steps/min for 5 minutes), resulting in firefighters reaching an average of 95% of max heart rate and 80% of max VO_2 (O'Connell et al., 1986). The elevated HR and VO_2 response, combined with the rise in core temperature, place a considerable challenge on the body and emphasise the importance of maintaining and/or improving levels of physical fitness in firefighters. Although clothing and gear can influence overexertion, the physical characteristics of the firefighters are also involved.

Multiple studies have demonstrated the potentially high prevalence of excess body weight and obesity in North American firefighting professionals (Clark et al., 2002; Kales et al., 1999; Martin et al., 2019; Munir et al., 2012; Poston et al., 2011). It is well established that physically demanding work requiring high exertion often precedes, or in some cases initiates, a myocardial infarction (MI) (Mittleman et al., 1999). Washburn et al. (1999) reported that an MI is the most frequent cause of death of firefighters, while Cady et al. (1985) reported that firefighters lacking a certain degree of physical fitness are considered 2.6 times more likely to suffer a MI than firefighters who are considered fit. Even firefighters who are considered experts in their field can experience a severe physiological challenge while wearing PPE, with multiple studies concluding that firefighters with an inadequate level of fitness could be exposed to a potentially dangerous situation (Davis et al., 1982; Calavalle et al., 2013; Morris et al., 2018a, 2018b; Perroni et al., 2010; Walker et al., 2015). Thus, increased levels of fitness can offset the effects of overexertion due to PPE and the physical characteristics of firefighters. Increased fitness levels can also impact the other major source of injury in firefighters.

As noted previously, soft tissue injuries are also a major source of injury for firefighters (Campbell et al., 2019). Evidence exists that increased fitness levels in firefighters are associated with a decrease in injury prevalence (Cady et al., 1979; Griffin et al., 2016; Lentz et al., 2019; Poplin et al., 2014). The research on aerobic fitness and injury incidence is the most prevalent and shows a beneficial relationship (Lentz et al., 2019; Poplin et al., 2014). However, there is evidence of the benefits of more comprehensive fitness profiles and reductions in injury incidence (Cady et al., 1979; Lentz et al., 2019; Poplin et al., 2016). Specifically, firefighters with a higher fitness profile were almost two times less likely to incur any type of injury and almost three times less likely to incur a sprain or strain (Poplin et al., 2016). Therefore, based on the benefits of high fitness levels in firefighters, it is important to have fitness guidelines and some type of structured fitness program in order to maintain and/or improve firefighter fitness levels.

In order to combat inadequate levels of fitness in firefighters, the International Association of Firefighters (IAFF)/International Association of Fire Chiefs (IAFC) published a set of recommendations, the Wellness/Fitness Initiative (WFI) (IAFF & IAFC, 2008), that outlines recommended fitness levels for individuals seeking candidacy as a firefighter. The IAFF and IAFC recommend that fitness levels be monitored on a regular basis even after admission to the fire service in order to ensure that firefighters are maintaining or improving physical fitness. Following the latter guideline, a local, professional fire department has monitored fitness levels over a decade while implementing mandatory exercise. Therefore, the purpose of this study was to retroactively evaluate the annual physical fitness performance of the members of this fire department to determine the effectiveness of monitoring fitness levels and implementing mandatory exercise on the maintenance of physical fitness levels for the members of this fire department.

2 Methods

2.1 Participants

As part of the annual (data from 2002–2017) health and fitness testing performed by the Bowling Green Fire Department (BGFD) in Bowling Green, KY, 153 firefighters had their physical fitness evaluated using standardised and recommended protocols published by the IAFF & IAFC (2008). The use of the previously recorded physical evaluation data for research purposes and the retrospective design was approved by the Institutional Review Board of the investigators' institution, and a legal authorisation from the BGFD was also properly obtained for this study. All data were extracted from the BGFD database and were analysed in a de-identified fashion. The number of firefighters present in the analysis per year (and per variable) is displayed in Table 1. The mean age of the firefighters in the BGFD each year is displayed in Table 2. Year one acts as the baseline year in that this was the first year that data was collected on a particular measure for an individual. As such, subsequent years would act as follow-up time points.

Table 1 Number of participants with datapoints separated by metric and year

Performance metric	*Year*															
	1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*	*13*	*14*	*15*	*16*
Flexibility	149	135	121	112	108	105	99	92	86	81	78	62	57	48	29	29
Grip	94	89	82	78	73	76	73	71	68	69	67	57	53	44	25	29
Push-ups	150	135	122	113	107	105	99	92	86	81	78	62	56	48	30	29
Static arm	149	134	122	113	106	103	99	92	86	81	75	62	56	48	30	28
Static leg	149	134	122	113	108	105	99	92	86	80	75	62	57	48	30	27
Plank	137	121	111	103	93	78	-	-	-	-	-	-	-	-	-	-

Table 2 Age of firefighters within department

Age	*Year*															
	1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*	*13*	*14*	*15*	*16*
Mean	33.9	35.1	35	35.5	35.4	35.4	35.8	36	36.5	36.8	37.4	38.1	38.6	38.7	38.3	38.5
SD	4.8	4.8	5.3	5.4	6.0	6.3	6.5	6.9	7.1	7.3	7.4	7.5	7.6	7.9	7.3	7.2

2.2 Procedures

Beginning in 2002, the BGFD began implementing exercise requirements of their respective firefighters as well as keeping records of the fitness scores of the members of their fire department. The department policy is that each firefighter is required to perform a minimum of 30 minutes of exercise per shift (i.e., 30 minutes per 24 hours worked on a 24 on, 48 off schedule). While it is possible that members of the fire department may exercise much more than the required minimum, the department log simply requires that the minimum be met. The type of exercise is self-selected by the firefighter, and education on types of exercise is provided on an as-needed basis by members of the department who possess nationally-relevant exercise and fitness certifications. However, it is not required that a firefighter meets with one of these members to design a program specific to their needs. Due to the nature of the self-reporting of exercise, it is also possible that a firefighter could have logged in the required 30 minutes but participated in minimal exercise. The aim of the requirement to complete 30 minutes of exercise per shift was to create a culture where exercise, and thereby fitness, is important to the well-being of the department.

The wellness and fitness evaluations are performed on an annual basis following standardised protocols (IAFF & IAFC, 2008). The data evaluated for this particular study was obtained by permission of the BGFD for evaluation of fitness maintenance of their respective firefighters. Standardised fitness testing with firefighters employs a protocol based on published criteria (IAFF & IAFC, 2008) which in this particular study, included the following evaluations: muscular strength, local muscular endurance, and flexibility.

For muscular strength, following manufacturer guidelines, each participant completed a hand grip strength test using a hand grip dynamometer (Takei Scientific Instruments Co., Ltd., Niigata City, Japan), as well as a static arm pull and static leg pull using the Jackson Strength Evaluation System (Lafayette Instruments, Lafayette, IN, USA). The hand grip device has been previously shown to be valid and reliable for testing grip strength (Balogun and Onigbinde, 1991). To complete the hand grip test, the participant grasped a hand grip testing device with their arm held at their side and squeezed as hard as they could. Three repetitions were completed for each hand (with a brief rest period between repetitions) and the maximum for each hand was used to calculate absolute hand grip strength (in kg). Relative grip strength was also calculated with the absolute grip strength divided by body mass (kg).

For the static arm pull, each participant stood on the dynamometer base plate, with feet shoulder-width apart and equidistant from the chain, which was connected to the bar held in the hands. The participant stood erect with knees straight, without arching the back, and arms held against the sides of the body. The participant then held the bar with a wide grip and bent the elbows to 90º so that the chain was taut. Next, the participant flexed maximally for 3 seconds and then slowly relaxed the arms while remaining standing for 30 seconds. Once the participant completed the 30-second recovery period, the evaluation was repeated, in the same manner, for a total of three trials. Peak force (in kg) was recorded for each trial and the highest of the three was recorded as their peak force for the static arm pull.

For the static leg pull, each participant stood upon the dynamometer base plate, with feet shoulder-width apart and equidistant from the chain, which was connected to the upper (inside) edge of the bottom cross-member of the V-grip handlebar (i.e., at the top of the participant's patella when the legs are straight). The participant then flexed the knees and hips until he could reach the handlebar. The participant then held the bar, looking straight ahead with the neck and back in neutral position and arms extended so that the chain was taut. The participant was then instructed to extend the legs at about 50% effort for a maximum of 3 seconds while exhaling. Following the 3-second leg extension, they were instructed to slowly relax the arms and legs and remain standing for a 30-second recovery period. Once that period ended, the participant was instructed to complete the same movement as before, but with maximum effort. Following another 30-second recovery period, the evaluation was completed for another trial in the same manner. A total of three trials were completed, with two at maximum effort. Peak force (in kg) was recorded for the 2nd and 3rd trials and the higher of the two was recorded as their peak force for the static leg pull.

The local muscular endurance assessment included two separate tests, a push-up test and a prone static plank test following previously published protocols (IAFF & IAFC, 2008). The push-up test has been previously shown to be valid and reliable for testing muscular endurance (McManis et al., 2000). The push-up test began with the participant in the standard 'up' position (hands pointing forward and under the shoulder, back straight, head up, using the toes as the pivot point). Next, the participant lowered their body by bending the elbows until the chin (or chest) touched a cup that was five inches tall and then returned to the 'up' position. The test was stopped when the participant strained forcibly, was unable to maintain the appropriate technique within two repetitions (or volitional fatigue), or performed a maximum of 80 push-ups. The prone static plank test involved the participant holding a prone plank position on a padded mat for as long as they could (up to a maximum of 4 minutes). The prone static plank test has been previously shown to be valid and reliable for testing muscular endurance (Bohannon et al., 2018). The plank position was held with the elbows on the mat at a 90º angle, the spine in a neutral position, and ankles held at a 90º angle. The participant would be given two verbal warnings if they erred from the previously described posture, but on the third occurrence of inability to maintain proper posture, the assessor terminated the test. The participant was permitted to perform the test for a maximum of 4 minutes or unless unable to maintain proper form after the 2nd warning. The BGFD only began performing the prone static plank test in 2012, so data is only available from that point until 2017 (most recently available year).

The next test of physical fitness involved a sit-and-reach test to evaluate flexibility. To conduct this test, the participant sat on the floor with their legs extended and feet flat (and shoeless) against a sit-and-reach trunk flexibility box (Baseline Evaluation Instruments, White Plains, NY). The sit-and-reach test has been previously shown to be valid and reliable for testing lower back and hamstring flexibility (Lemmink et al., 2003). To complete this test, the participant slowly reached forward with both hands (one on top of the other) as far as possible and held that position for approximately 2 seconds. They were encouraged to exhale and drop their head between their arms when reaching and informed that their knees must remain extended. Each participant was given 3 trials and the sit-and-reach trunk flexibility box was reset following each trial. Reach distance was recorded in inches and then converted to metric units (centimetres).

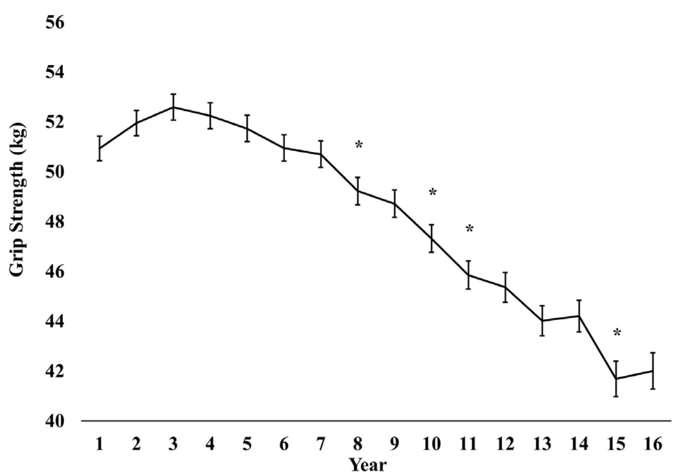
2.3 Statistical analysis

The retrospective and observational nature of the study meant that participants' baseline measure for each performance metric did not occur at the official start of the study (i.e., 2002). To address this and better address the purpose of the study, data were recorded where an individual's first year in the study was coded as year 1 with all subsequent years being based off of that year. Linear mixed model analyses were employed to examine changes over time for each of the dependent variables (handgrip strength, static arm pull strength, static leg pull strength, push-ups completed, plank hold time, and flexibility). Assumptions of normality and homoscedasticity were assessed via visual inspection of QQ and predicted/residual plots. When assumptions were met, a model was fit using a maximum likelihood estimation method and a heterogeneous autoregressive error covariance structure using SPSS software (Version 26, SPSS, Inc., Chicago, IL). When assumptions were not met, robust linear mixed effects models were employed using the rlmer function in the *robustlmm* package using R (Version 3.6.1, R Core Team, Vienna, Austria) (Koller, 2016). Bonferroni post-hoc analyses were carried out where each time point was compared back to the previous year (year 1 vs. year 2, year 2 vs. year 3). Cohen's D effect sizes were calculated as the difference between successive years divided by the standard deviation of the difference, estimated as the standard error of the difference * $\sqrt{degrees\ of\ freedom + 1}$. Statistical significance was defined as a *p*-value less than 0.05. Data are presented as mean and standard deviation unless otherwise specified.

3 Results

A robust linear mixed model revealed handgrip strength performance significantly declined from year 7–8 (*p* = 0.009, *d* = –0.207), 9–10 (*p* = 0.039, d = –0.24), 10–11 (*p* = 0.034, *d* = 0.239), and 14–15 (*p* = 0.014, *d* = 0.624). Handgrip strength did not significantly change from year 1–2 (*p* = 0.069), 5–6 (*p* = 0.809), or 12–13 (*p* = 0.247) or any other year (all *p* = 0.999). Means and standard errors for hand grip performance can be found in Figure 1.

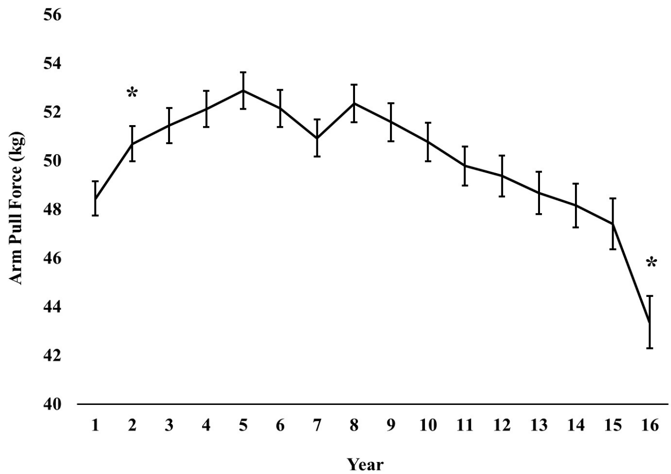
Figure 1 Hand grip strength performance



Note: *Represents a significant difference from the year directly previous at the p < 0.05 level.

A robust linear mixed effects model revealed static arm pull performance to significantly improve from year 1–2 (*p* < 0.001, *d* = 0.253). Additionally, a significant decline in performance was noted in year 15–16 (*p* = 0.03, *d* = –0.644). Static arm pull performance did not significantly change from years 6–7 (*p* = 0.851), 7–8 (*p* = 0.456), or any subsequent year (*p* = 0.999). Means and standard errors of static arm pull performance can be found in Figure 2.

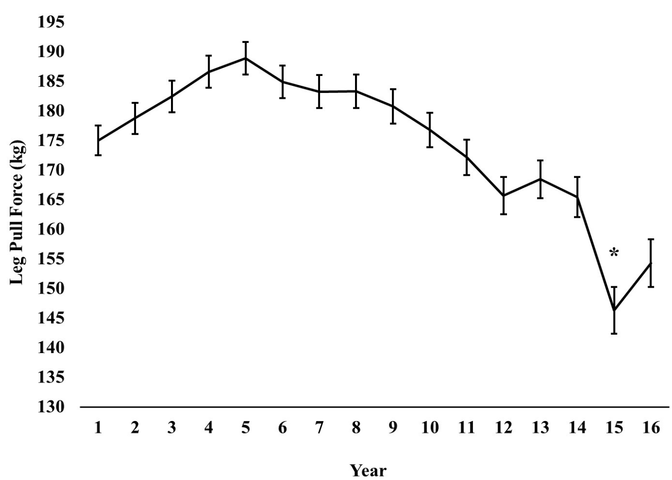
Figure 2 Static arm pull strength performance



Note: *Represents a significant difference from the year directly previous at the $p < 0.05$ level.

The assumption of normality was violated so a robust linear mixed model was used. A significant decrease in static leg pull strength occurred from year 14–15 ($p < 0.001$, $d = -0.587$). No other change from year to year was observed (year 11–12: $p = 0.537$, all other: $p = 0.999$). Means and standard errors of static leg pull performance can be found in Figure 3.

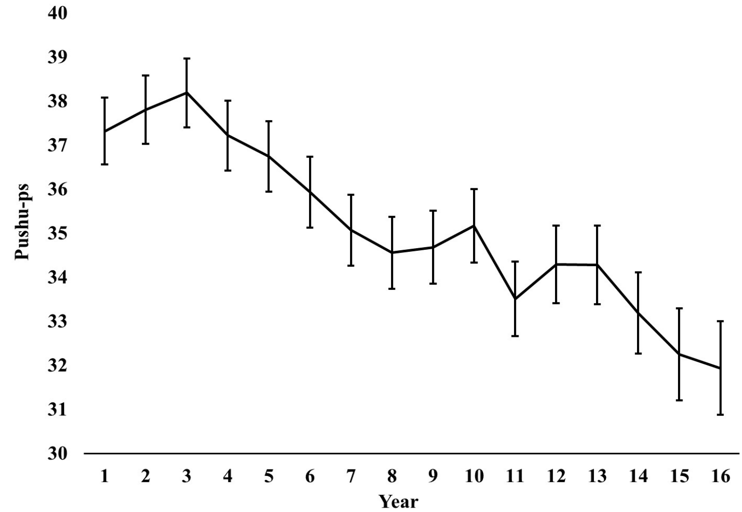
Figure 3 Static leg pull strength performance



Note: *Represents a significant difference from the year directly previous at the $p < 0.05$ level.

Push-up performance did not significantly change from year to year (year 10–11: $p = 0.194$; all other: $p = 1.00$). Means and standard errors of push-up performance can be found in Figure 4.

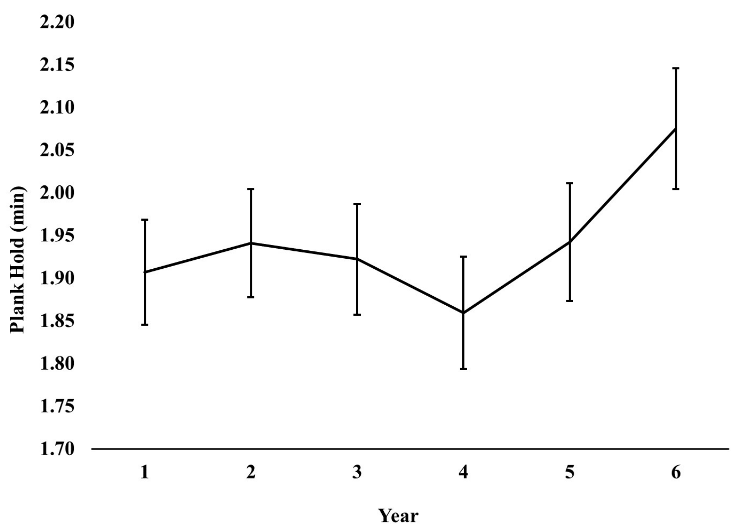
Figure 4 Push-up performance



Note: *Represents a significant difference from the year directly previous at the p < 0.05 level.

A robust mixed effects analysis was performed due to the assumption of normality being violated. The analysis revealed plank performance did not change for year 1–2, 2–3, 3–4 (p = 1.000), 4–5 (p = 0.613), 5–6 (p = 0.132). Means and standard errors of plank hold performance can be found in Figure 5.

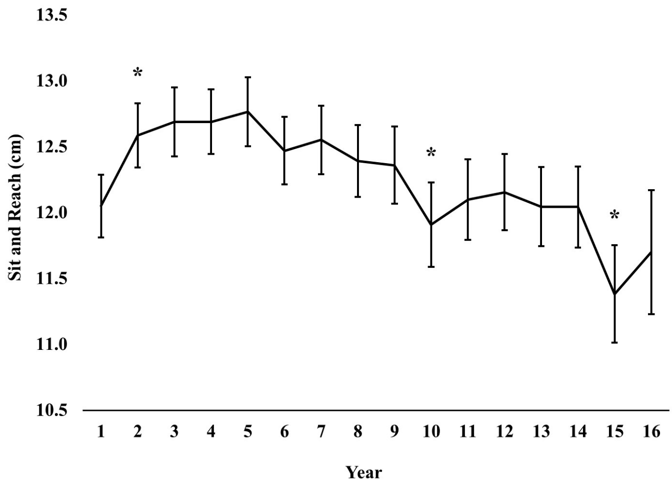
Figure 5 Plank hold performance



Note: *Represents a significant difference from the year directly previous at the p < 0.05 level.

A linear mixed effect model revealed that flexibility significantly improved from year 1–2 (p < 0.001, d = 0.263). Additionally, flexibility was observed to significantly decrease from years 9–10 (p = 0.396, d = –0.188) and 14–15 (p = 0.037, d = –0.321). No other yearly changes in flexibility were observed (5–6: p = 0.178, all other (p = 0.999). Flexibility means and standard errors are displayed in Figure 6.

Figure 6 Flexibility performance



Note: *Represents a significant difference from the year directly previous at the p < 0.05 level.

4 Discussion

The job requirements of firefighters are characterised by high physiological demands and a sufficient level of physical fitness can lessen the risk of musculoskeletal injury. The purpose of this retrospective study was to evaluate the ability of firefighters to maintain physical fitness levels over time as a response to a mandatory daily exercise requirement. Over the 15-year period, physical fitness was evaluated annually by the fire department. Based on the available data, it appears that the mandatory daily exercise was effective in reducing the expected decline in physical fitness of the firefighters over time.

According to the American College of Sports Medicine (ACSM) guidelines, individuals can expect to experience a decline in hand grip performance as they age (ACSM, 2017). Specifically, the average rate of decline is approximately a decrease of one kg of hand grip strength every 4 years. With the overall average age of firefighters of this department increasing by 18.2 years, the predicted decline in hand grip strength would have been 4.55 kg; however, the firefighters in this study exhibited a decrease in hand grip strength of 8.93 kg over the 15 year study period. Thus, the hand grip strength in these firefighters exhibited a higher than normal, and expected, decline following the implementation of the exercise requirement. However, it should be noted that this decline might be due to the retirement and/or hiring of firefighters in this department, which could affect the average value reported for each year.

When considering both the upper and lower extremity strength measures (static arm pull and static leg pull, respectively), both values remained significantly elevated for several years following the implementation of the required exercise per shift. However, this static arm pull strength improvement was maintained for approximately 12 years by the department while the static leg pull strength was maintained for approximately seven years. At those points, each respective variable tended to exhibit a significant decline from its initial improvement and maintenance. As previously mentioned, considering the average age of the department increasing by 18.2 years over the 15-year assessment period, some context must be considered in terms of what would be expected in a normal aging population. As individuals age from 20 to 50, overall muscular strength declines by about 10%, on average (Powers and Howley, 2017). This decline would equate to an average strength loss of approximately 0.33% per year (Powers and Howley, 2017), which would translate to a predicted 6.01% decline in strength. For the firefighters in this study, arm and leg strength declined by 10.49% and 11.84%, respectively. While the overall reported decline is greater than the predicted decline, it may not perfectly represent what occurs per year or decade. Based on the available evidence, it appears that the firefighters saw initial improvements in muscular strength that levelled off and eventually declined, but it should be noted that the strength values for these firefighters were maintained for a number of years as their average age increased. It is possible with the policy change, the required time spent exercising allowed the firefighters to initially improve their muscular strength for a few years while avoiding the previously reported normal, age-related decline. However, it is likely that larger strength decrements occur near the end of the age range noted previously. With the average age of this group of firefighters representing the end of that age range during the last year of this study, it is plausible that an exponential rather than linear loss of strength could explain the large overall decrease. Additionally, other factors, such as detraining due to a decrease in training volume or intensity, a decrease in the total number of hours of sleep per day, or reduced nutritional quality of diet during this time period might have influenced the average values of these variables (Hortobagyi et al., 1993; Chang and Chen, 2015; Thomas et al., 2016). Therefore, this finding needs to be confirmed by further study.

Also noted in the ACSM guidelines, it is expected that individuals will experience a decline in push-up performance as they age (ACSM, 2017). According to these guidelines, the average rate of decline is approximately one less push-up every two years. Accordingly, the predicted push-up performance should have decreased by 9.1 reps for the firefighters in this study, yet, push-up performance only declined by 5.39 push-ups. This data appears to suggest that the exercise requirement of the department allowed the firefighters to maintain their muscular endurance and offset the expected decline, at least as it pertains to the push-up exercise.

The fire department did not begin implementing the static plank hold test until 2012 (ten years after other variables began being collected). Prior to that point, a curl-up test was performed but the IAFF/IAFC guidelines recommended replacing that test with the static plank hold test after the fire department in the current study had begun their annual assessments (IAFF & IAFC, 2008). Similar to other evidence on changes in upper body muscular endurance (Backman et al., 1995), in the 5-year period where data is available, the static plank hold performance was maintained until a significant improvement was experienced in the most recent year. Over that five-year period, plank time increased around ten seconds. While this will need to be further evaluated as more data becomes available, it is perhaps an encouraging sign that the plank hold performance is seeing marked improvement. The implication of improved trunk strength would be very important to the safety and performance of the firefighters (Peate et al., 2007).

In addition to the other declines noted in the ACSM guidelines, it can be expected that as individuals age, they will experience a decline in flexibility (ACSM, 2017). According to these guidelines, the average rate of decline for the sit-and-reach test is approximately 0.6 cm per year. Based on the increase in age seen in this study, it is predicted that the firefighters' flexibility would have decreased by 10.92 cm. The sit-and-reach performance of the firefighters in this study decreased 0.35 cm over the 15-year study period. This data appears to suggest that the fitness requirement of the department allowed the firefighters to, at a minimum, closely maintain their flexibility over the time period studied and drastically reduce the typical decline associated with flexibility. In fact, with the average age remaining fairly stable from 2003–2007 and the flexibility exhibiting a significant improvement from baseline and maintaining that improvement for the same time period, it could be reasoned that the exercise requirement might have led to flexibility improvements during the initial few years of fitness testing. Resistance exercise utilising a full range of motion is noted to lead to improvements in flexibility similar to changes seen from flexibility training alone (Morton et al., 2011). Thus, one possible explanation is that if firefighters from this department included full range of motion resistance exercise in their training, bodyweight or external load, it might have helped maintain flexibility. It is also possible that the firefighters in this department chose to incorporate their own flexibility training; however, the actual programming followed was not documented so whether flexibility training was performed, or not, is not known.

There are a number of limitations to consider with this particular study. The participants were only required to perform a minimum of 30 minutes of exercise per shift. If any participant chose to complete more exercise than the minimum, that information was not documented. It is certainly possible that many (if not all) of the firefighters performed much more than the required minimum. It is also possible that many (if not all) of the firefighters only performed the required minimum. Due to this information not being documented, it is difficult to relate overall fitness improvements to any one individual participant based on their specific training. Also of note, perhaps more consideration should be given to the functionality of the tests used to track fitness variables. While the hand grip, push-up, plank, and flexibility tests are all classic tests that are valid and reliable tests to evaluate the physical fitness of the general population, perhaps more functional and firefighting task-specific tests of physical fitness should be tracked on an annual basis with this specific population in the future. There is recent evidence to suggest that this functional testing of firefighters could provide important information to the firefighting department as to the preparedness of their firefighters (Mamen et al., 2019).

In addition, the firefighters were not required to perform a specific type of exercise, but were allowed to self-select based on their own enjoyment and/or abilities/comfort level. Supervisors checked exercise logs and while it is certainly possible that a person logged in and performed no exercise, from the author's discussion with the firefighters it would appear to be highly unlikely. In many cases, firefighters were exercising simultaneously with other firefighters and while they did not necessarily exercise together or perform the same exercise, it is very unlikely that a firefighter signed in but did not perform any exercise while their peers exercised nearby. Once again, the aim of the department was to encourage participation but not to require any specific type of exercise so the firefighters could self-select an exercise type they enjoyed and were likely to be able to perform on a consistent basis. Authors were not provided access to these logs, so we do not have adherence data or information related to consequences if exercise requirements were not met. So based on the retrospective nature of this study, it is difficult to definitively establish any cause-and-effect relationship between the exercise training requirement and the fitness scores. However, it appears likely that based on the available evidence that the daily exercise training requirement did lead to improvements in the fire department as a unit. An additional limitation is the lack of aerobic fitness and body composition data present in the current study. This information was inconsistently collected and the necessary information to make reliable and valid estimations of these values was incomplete. Therefore, we were not able to analyse any variables related to aerobic fitness or body composition in the current study.

Due to the team-nature of this particular occupation in successfully completing their job, it can certainly be reasoned that if fitness levels are maintained at an acceptable level, this at least suggests that the firefighters should be able to perform their jobs with a greater level of physical fitness (and thereby success) as well as a lower risk of injury. However, we must also note that we were not privy to any documented injury information, so this is purely speculative based on the information available.

5 Conclusions

Based on these results, a consistent improvement in muscular strength and flexibility occurred during the first several years tested; however, these improvements levelled off thereafter (and in some cases experienced a significant year-to-year decline). Based on these findings, the proposed 30-minute exercise requirement does not appear to provide a stimulus to offset declines in all fitness variables. Thus, providing unstructured exercise does not appear to meet all of the needs of these firefighters. However, it should be noted that the 30-minute unstructured exercise requirement did allow this group of firefighters to maintain and/or improve some fitness variables. Future work should attempt to more closely document not only if the minimum level of exercise was completed, but also what types of exercise each participant performed as well as how many total minutes of exercise was performed during each shift. This information could aid in the development of a prescriptive, progressive training program that is easy to design and implement by any member of the firefighting department. Additionally, this information would help to establish a relationship between the daily exercise requirement, exercise mode utilised, and injury incidence or rates of musculoskeletal discomfort. This work is vital to the health and safety of firefighters, as well as, to the public individuals they serve.

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