ORIGINAL ARTICLE

Comparison of Supervised and Telehealth Delivery of Worksite Exercise for Prevention of Low Back Pain in Firefighters

A Cluster Randomized Trial

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Objective: This study assessed worksite exercise delivered by on-site supervision (supervised) or telehealth to reduce lost work time (LWT) related to low back pain (LBP) in firefighters. **Methods:** A cluster randomized controlled trial assigned 264 career firefighters to supervised ($n = 86$) or telehealth ($n = 95$) back and core exercises 2×/week for 12 months, or control ($n = 83$). **Results:** 58.0% (153/264) of participants reported LBP and 7.6% (20/264) reported LWT related to LBP (control $n = 10$, supervised $n = 5$, telehealth $n = 5$). Participants in the control group experienced 1.15 times as many hours of LWT as the supervised group, and 5.51 times as many hours of LWT as the telehealth group. **Conclusions:** Worksite exercise, delivered by on-site supervision or telehealth, can reduce LWT related to LBP in career firefighters.

Keywords: exercise, firefighters, injuries, lost work time, low back pain, prevention

Low back pain (LBP) is one of the leading reasons for disability in firefighters and greatly impacts quality of life and preparedness.[1] Previous research in firefighters reported that poor back muscle endurance was associated with an increased risk of developing LBP.[2] Research also demonstrated that a worksite exercise intervention focused on back and core muscle strength training is safe and improves muscle endurance in firefighters.[3] While exercise has been shown to be effective for prevention of LBP in other occupations,[4,5] the effectiveness of exercise for prevention of LBP in firefighters has not been studied using clinically relevant outcomes, such as absenteeism (eg, lost work time).

Previous worksite exercise programs in firefighters were delivered with direct onsite 1-on-1 supervision of exercise training at fire stations.[3] Although effective, this method can be costly and challenging to implement on a larger scale in fire departments with many fire stations, fire stations spread out over a wide geography, fluctuating work schedules, and changes in fire station assignments. Telehealth presents an interesting alternative to direct onsite supervision of exercise training. If demonstrated to be as effective as direct onsite 1-on-1 supervision, telehealth could provide a much larger number of firefighters with an accessible and flexible tool to facilitate worksite exercise training, improve endurance of back and core muscles, reduce the risk of developing LBP, and prevent lost work time related to LBP. However, it is currently unclear if back and core exercise training can reduce lost work time related to LBP in firefighters, and the effectiveness of using telehealth to deliver a worksite exercise intervention program has not been assessed.

The objectives of this study were therefore to: (1) determine if a worksite exercise intervention program aimed at training back and core muscles could reduce lost work time related to LBP in firefighters, and (2) compare the effectiveness of direct onsite 1-on-1 supervision to telehealth.

METHODS

Study Design

A mixed methods, three-group, cluster randomized controlled trial was conducted to compare the effectiveness of a 12-month worksite exercise intervention delivered via direct 1-on-1 onsite supervision or telehealth on clinically relevant outcomes related to LBP in firefighters. The study incorporated pragmatic design features to inform broader implementation.

Setting

Recruitment and interventions took place at 78 fire stations from four fire departments in the greater Tampa Bay region of Florida, USA, including Hillsborough County Fire Rescue, St. Petersburg Fire & Rescue, Tampa Fire Rescue, and Temple Terrace Fire Department. Enrollment, screening, and assessments took place at fire department facilities while participants were off-duty. Interventions took place at fire stations while participants were on-duty.

Participants

The study population consisted of career firefighters recruited from four fire departments with a total of approximately 2000 firefighters. To be included, participants had to be career firefighters on full active duty without work restrictions, in regular service, and assigned to a standard fire station from a participating fire department. Exclusion criteria were: (1) current workers' compensation or personal injury case; and (2) pregnant women.

Candidates for participation were recruited by face-to-face presentations by study personnel, advertisement at fire departments, and word of mouth. Firefighters who expressed interest underwent a telephone screen with study personnel. Eligible candidates then provided written informed consent, completed screening questionnaires, underwent pulse and blood pressure assessment, a urine pregnancy test (females only), and were interviewed by study

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The lead author (JM) was part of a team that developed the telehealth exercise system discussed in this manuscript, yet does not own its intellectual property and does not financially benefit from it.

The study was approved by the Institutional Review Board of the University of South Florida (protocol # 00020388). Subjects gave written informed consent prior to participation.

The authors report no conflicts of interest.

Clinical significance: A worksite exercise program was found to be clinically effective in reducing lost work time related to low back pain (LBP) in career firefighters. This program, particularly if implemented via telehealth, could lessen the burden of LBP and disability in the fire service.

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personnel to determine final eligibility. The study was approved by the institutional review board of the University of South Florida.

Outcome Measures

The primary outcome measure was the amount of lost work time (ie, hours, days, shifts) related to LBP over a 12-month period, which was selected because it reflects both incidence and duration, can be used to estimate the costs of lost productivity, and has been used in prior studies, providing relevant data to estimate the required study sample size.[6–9] Lost work time was defined as the number of hours when a participant when unable to work (absenteeism) or only able to perform restricted work activities (presenteeism), consistent with terminology from the Occupational Safety and Health Administration (OSHA).[10] LBP was defined as an injury (eg, sprain, strain, trauma) or illness (eg, infection, neurologic disorder) that resulted in pain or discomfort below the rib cage and above the lower buttocks.[10,11]

Data on the primary outcome were obtained from various sources, including participant self-reports (eg, questionnaires, interviews), administrative documents from the fire departments (eg, internal report forms, surveillance data, payroll data), and workers' compensation records (eg, injury reports, summary treatment records) using methods adapted from previous research in related areas.[12–15] Participants were instructed to report new LBP to study personnel as soon as it occurred and were also asked retrospectively about LBP at each study follow-up. Self-reported information included timing of onset, duration, and frequency of LBP, as well as severity, healthcare utilization, and impact of LBP on work status.[11] Administrative and worker's compensation data were only obtained from a fire department liaison (eg, occupational health nurse, human resources administrator) after study completion to ensure the confidentiality of this information and limit the possibility of misuse. Self-reported and administrative data were then compared to reconcile potential discrepancies prior to analysis.

Other outcome measures included back and core muscular endurance as assessed by the Modified Biering-Sorensen Test (MBST)[16,17] and Prone Plank Test (PPT),[18] respectively, which are recommended for use in firefighters.[1,3] Data were also collected on risk factors and confounders for LBP, exercise training, and muscular endurance, including the Oswestry Disability Index (ODI)[19] Short Form 12 questionnaire (SF-12),[20] Back Beliefs Questionnaire (BBQ),[21] modified Mediterranean Diet Score questionnaire (mMDS),[22] body mass index (BMI),[13,23] and Functional Movement Screen (FMS).[24–27] Questionnaires were collected at 0, 3, 6, 9, and 12 months while measures requiring physical assessments were collected at 0 and 12 months.

Sample Size Calculation

Based on data obtained from various fire departments, we estimated that 20% of firefighters would experience LBP in a 12-month period, 50% of whom would experience lost work time related to LBP, losing on average 30.0 shifts of 24 hours, or 720 hours, resulting in mean lost work time related to LBP of 72.0 hours per firefighter over 12 months. We estimated that participants undergoing worksite exercise training for 12 months would experience a 40% reduction in lost work time related to LBP, or 43.2 hours per firefighter over 12 months. We estimated a wide variance in the primary outcome measure, with a common standard deviation of 72.0.[28] For a two-sided comparison to provide 80% power with alpha set at 0.05, a cluster randomization design with an average cluster size of 5, an estimated intracluster correlation coefficient (ICC) of 0.01,[3] and a variance inflation factor (VIF) of 1.04, we estimated that 88 participants were required in each study group.

Randomization

Fire stations were selected as the unit of randomization to improve study logistics, acknowledge that firefighters must work within fire station teams, and reduce the possibility of contamination across study groups. There was minimal risk of bias due to cluster effect given the large number of fire stations available in this study. A similar cluster randomization was effectively used in a previous study of worksite exercise training in firefighters.[3]

To balance study groups, fire stations were stratified within each department based the number of firefighters assigned, mean age of firefighters, and number of emergency responses. Fire stations with similar characteristics were grouped in blocks of 3. A randomization sequence was generated for each block and placed in sealed envelopes that were only opened after baseline assessments were completed for all participants in that block of fire stations. Participants were then randomly assigned by fire station the three study groups: (1) supervised exercise, (2) telehealth exercise, or (3) control.

Blinding

All study staff were blinded to group assignment at enrollment, screening, and baseline assessment. The principal investigator was blinded to group assignment throughout the study period, except in the case of a serious adverse event or other urgent matter requiring unblinding. The statistician was blinded to group assignment throughout the study and did not determine eligibility for participation.

Interventions

Supervised Exercise

Participants in this group were scheduled to perform physical fitness exercises twice a week throughout the 12-month study period while on duty at the fire station. Each exercise session was expected to take 10 to 15 minutes, but participants were not relieved of their usual duties (eg, emergency responses) to perform exercises. Exercises included four motor control exercises (Cat Camel, Birddog, Curl-up, Side Bridge) and back extension exercise using a variable angle Roman chair (VARC). The motor control exercises were designed to elicit low-intensity activation of the muscles thought to aid in core stability (eg, transverse abdominis, multifidus, quadratus lumborum, and oblique abdominals).[29] Participants performed one set of each motor control exercise and attempted to progress through levels of difficulty over time by varying their body position or movements. After the motor core exercises, participants completed one set of dynamic progressive resistance exercise for back extension on a VARC with 6 angular positions.[3] Each repetition was expected to take 12 seconds to complete, and participants were instructed to continue until volitional fatigue or a maximum of 30 repetitions. Participants attempted to progress through levels of resistance by modifying the VARC angle and hand positions using a standardized progression protocol.[3] Exercises were performed under direct 1-on-1 supervision by a study exercise specialist who helped guide the performance of exercise movements, documented details about the exercises completed, monitored adherence, and recorded reasons for non-adherence using electronic exercise logs that were reviewed periodically by other study staff.

Telehealth Exercise

Participants in this group were expected to perform the study exercises under the same conditions as those described above for the supervised exercise group (ie, twice a week while on duty at their home fire station). However, following an initial orientation session by study staff, participants in this group received subsequent exercise instruction and guidance using a telehealth system developed by the research team and a private company (WebExercises Inc, Novato, CA). The system included the following features: (1) video and audio instruction on study exercises; (2) ability to contact study staff with questions about study exercises; (3) ability to interact with

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study staff by telephone, email, or text; (4) automated email and text reminders to perform study exercises according to prescribed schedule (ie, twice weekly for 12 mo); (5) ability to record exercise performance (eg, dates, repetitions, sets, resistance level, perceived difficulty); (6) ability to record reasons for missed exercise sessions; (7) automated exercise performance reports; (8) remote monitoring of exercise adherence and progression. Instructions provided by the telehealth system (eg, exercise progression) were intended to be the same as those provided by study exercise specialists to participants in the supervised exercise group.

Control

Participants in the control group received a 60-minute, 1-on-1 educational session delivered by study staff with information about exercise, physical fitness, and physical activity from the *American College of Sports Medicine (ACSM) Position Stand—Quantity and Quality of Exercise for Developing and Maintaining Cardiorespiratory, Musculoskeletal, and Neuromotor Fitness in Apparently Healthy Adults: Guidance for Prescribing Exercise*,[30] along with wellness and nutrition.[31] Participants in all three study groups were advised to continue with their usual physical fitness routines in addition to the study interventions.

Data Analysis

Standard descriptive statistics were provided for continuous (ie, means, standard deviations, and 95% confidence intervals (CIs)) and categorical (ie, frequencies, proportions) variables, comparing baseline characteristics among the three study groups. Since the primary outcome measure was not normally distributed, zero-inflated Poisson (ZIP) regression models combining Poisson regression and logistic regression were used to compare study groups.[32] Poisson regression assessed the primary outcome (quantity of lost work time in hours), while logistic regression assessed the incidence of lost work time. Changes in MBST and PPT from baseline to 12 months were compared across study groups using analysis of variance. Exercise adherence, as measured by the percent of completed versus prescribed ($n = 104$) exercise sessions, was compared between the supervised and telehealth groups for each 3-month increment using independent *T* tests. Associations between exercise adherence and changes in MBST and PPT were assessed using Pearson's correlation analyses. Preliminary assessment of risk factors that might impact the primary outcome was conducted. Relationships among pertinent variables (eg, BMI, back and core muscular endurance, ODI, adherence, history of low back pain) were compared using Pearson's correlation analyses or T tests, as appropriate. All analyses were based on intention to treat, with alpha set at 0.05, and conducted with SAS (Cary, NC).

RESULTS

Enrollment

A total of 364 firefighters were assessed for eligibility, but 100 failed screening because they were unable or unwilling to participate ($n = 6$), were not a career firefighter ($n = 4$), were involved in workers' compensation or personal injury litigation ($n = 4$), had participated in a previous study on worksite exercise ($n = 2$), or did not pursue additional screening ($n = 84$). Of the 264 participants who enrolled in the study, 28 withdrew prior to the 12-month follow-up due to LBP ($n = 3$), other illness ($n = 5$), being placed on light duty ($n = 4$), change in employment ($n = 2$), pregnancy ($n = 1$), time constraints ($n = 6$), or other reasons ($n = 7$). A total of 217 (82.2%) completed end of trial assessments for the primary outcome, and 200 (75.8%) completed end of trial fitness assessments. Participant flow throughout different study stages is shown in Fig. 1.

Demographic Characteristics

Baseline demographic characteristics are summarized in Table 1. A total of 175 (66.3%) reported a history of LBP and 31.8% were obese (BMI $\geq$ 30). Significant differences were noted between study groups at baseline for ODI ($P = 0.035$) and FMS ($P = 0.025$), but these differences did not appear clinically meaningful.[25,33] For ODI, the mean value for each groups was within the lower half of the "minimal disability" category of 1% to 20%.[19] For FMS, the mean value for each group was above the cutoff score of $\leq$14 for high injury risk.[25] At baseline, core muscular endurance was correlated with BMI ($R = -0.364$, $P < 0.001$), BBQ ($R = 0.172$, $P = 0.006$), ODI ($R = -0.297$, $P = 0.031$), and mMDS ($R = 0.154$, $P = 0.014$), while BBQ was correlated with mMDS ($R = 0.129$, $P = 0.037$). Participants with a history of LBP had higher BMI ($P = 0.003$), poorer BBQ ($P = 0.006$), and better mMDS ($P = 0.029$).

Primary outcome (lost work time due to LBP): Reconciliation of self-report and administrative data revealed that many occurrences of LBP were not reported to the administration and did not result in lost work time. While reconciliation was not necessary in most cases, the reconciliation process was effective to precisely identify the quantity of lost work time in hours. For example, a participant may have self-reported one lost shift and administrative data was used to clarify that a lost shift was a certain number of hours. During the 12-month trial period, 153 (58.0%) (153/264) of participants reported LBP and 20 (7.6%) reported lost work time related to LBP (control: $n = 10$, supervised exercise: $n = 5$, telehealth: $n = 5$), of which 4 involved workers' compensation and 16 did not. For all participants, the total (mean) hours of lost work time related to LBP was 1201.0 (14.5) for the control group, 523.0 (6.1) for the supervised exercise group, and 109.0 (1.2) for the telehealth exercise group. Among the 20 participants who reported lost work time related to LBP, the mean ($\pm$SD) hours of lost work time was 120.1 ± 181.6 for the control group, 104.6 ± 155.8 for the supervised exercise group, and 21.8 ± 4.9 for the telehealth exercise group. Results of the ZIP regression analyses are shown in Table 2. Significant differences were noted among the groups in the quantity of lost work time related to LBP, the primary outcome for this study. For each hour of lost work time due to LBP in the supervised exercise group, the control group experienced 1.15 hours (95% CI: 1.04, 1.27; $P = 0.008$). For each hour of lost work time due to LBP in the telehealth exercise group, the control group experienced 5.51 hours (95% CI: 4.53, 6.70; $P < 0.0001$), and the supervised group experienced 4.8 hours (95% CI: 3.9, 5.9; $P < 0.0001$). No significant differences were noted among the groups in the incidence of lost work time related to LBP among the groups. Participants who reported LBP during the 12-month trial period had higher BMI ($P = 0.01$) and poorer back muscular endurance ($P = 0.009$) than those who did not report LBP during the study period. The number of participants with lost work time due to LBP ($n = 20$) was too small to analyze risk factors.

Other Measures

Exercise adherence was lower than expected and declined at each subsequent 3-month interval. Overall, there was no significant difference in exercise adherence between the supervised and telehealth exercise groups, though the supervised exercise group had higher adherence for months 10 to 12. For the two exercise groups overall, the vast majority (86%) of missed exercise sessions were due to leave (eg, administrative, annual, personal, sick) and time constraints (eg, training, out on call, other). For the supervised group, the top three reasons for missed sessions were time constraints—out on call (38.6%), annual leave (16.9%), and personal/administrative leave (14.1%). For the telehealth group, the top three reasons for missed sessions were annual leave (38.6%), time

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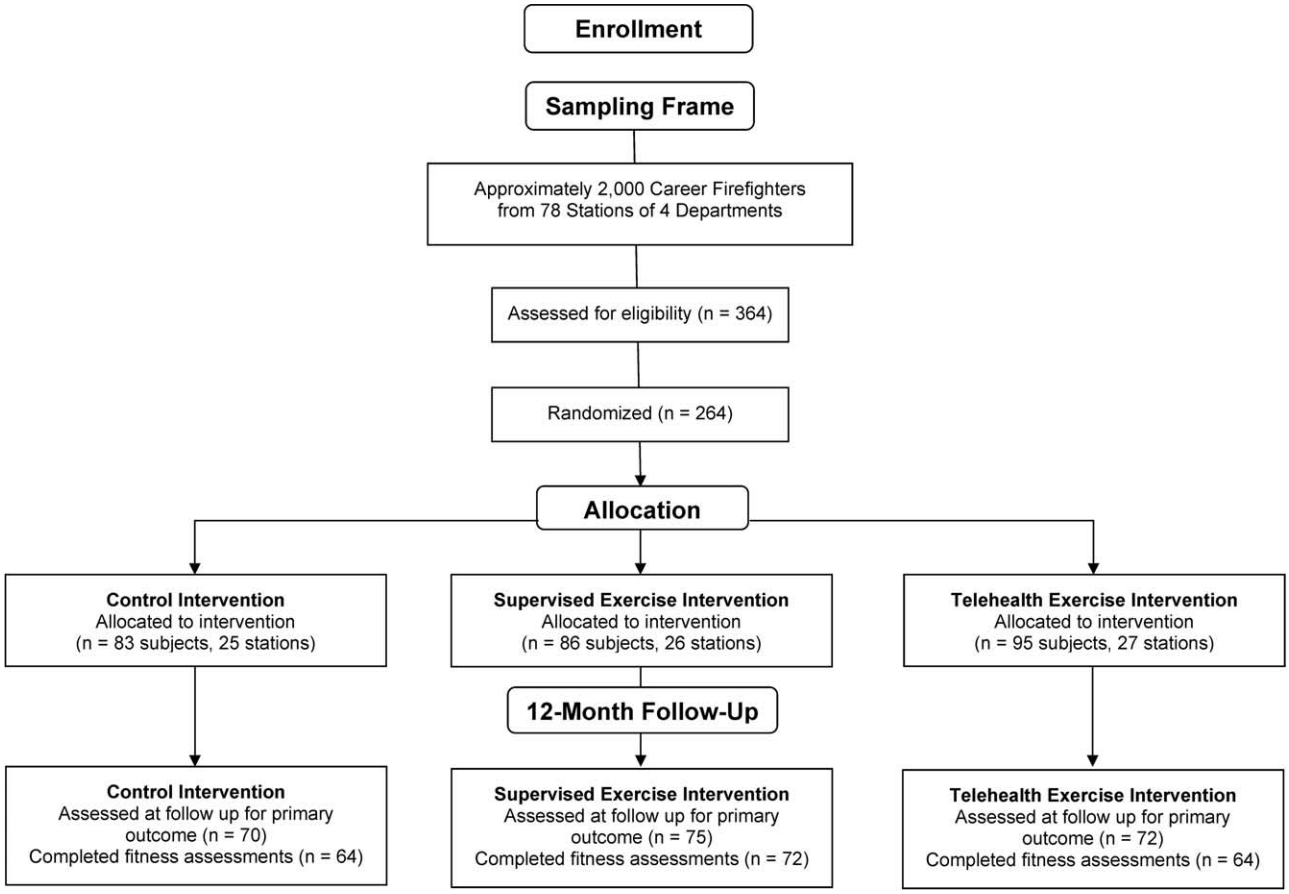

FIGURE 1. CONSORT diagram depicting participant flow through various stages of study.

TABLE 1. Baseline Demographic Characteristics of the Participants

Variable	Control ($n = 83$)	Supervised Exercise ($n = 86$)	Telehealth Exercise ($n = 96$)	Total ($n = 264$)	P value
Continuous variables (mean ± SD)					
Age (y)	33.6 ± 8.4	35.9 ± 8.5	35.8 ± 8.7	35.1 ± 8.6	0.153
Years as career firefighter (y)	7.7 ± 7.1	9.4 ± 7.7	9.4 ± 8.2	8.9 ± 7.7	0.226
Height (m)	1.80 ± 0.08	1.79 ± 0.08	1.79 ± 0.08	1.79 ± 0.08	0.489
Weight (kg)	90.4 ± 17.5	93.0 ± 16.5	91.8 ± 16.6	91.7 ± 16.8	0.616
Body mass index (kg/m^2)	27.8 ± 4.3	28.9 ± 3.8	28.7 ± 4.3	28.5 ± 4.2	0.145
Oswestry Disability Index (0–100)	5.4 ± 4.4	6.4 ± 5.7	10.0 ± 5.3	7.4 ± 5.5	0.035
Back Beliefs Questionnaire (9–45)	28.2 ± 6.1	28.64 ± 5.5	27.5 ± 6.0	28.1 ± 5.8	0.446
SF-12 physical component score (0–100)	55.2 ± 3.6	55.0 ± 3.7	54.9 ± 4.1	55.0 ± 3.8	0.829
SF-12 mental component score (0–100)	54.3 ± 5.2	53.5 ± 6.8	53.9 ± 6.6	53.9 ± 6.2	0.707
Nutrition mMDS total (0–43)	22.8 ± 5.0	22.5 ± 4.1	23.2 ± 5.1	22.8 ± 4.7	0.644
Back muscular endurance (s)	74 ± 35.6	68.1 ± 26.2	74.6 ± 31.2	72.3 ± 31.2	0.321
Core muscular endurance (s)	108.1 ± 48.6	110.8 ± 51.8	109.9 ± 51.6	109.6 ± 50.6	0.941
Functional movement screen (0–21)	18.3 ± 1.8	17.6 ± 3.2	16.5 ± 5.5	17.5 ± 3.8	0.025
Categorical variables (n (%))					
Sex					0.803
Female	10 (12.0%)	9 (10.5%)	13 (12.7%)	32 (12.1%)	
Male	73 (88.0%)	77 (89.5%)	82 (86.3%)	232 (87.9%)	
Low back pain history					0.195
No	33 (39.8%)	23 (26.7%)	33 (34.7%)	89 (37.6%)	
Yes	50 (60.2%)	63 (73.3%)	62 (65.3%)	175 (66.3%)	
Body mass index categories					0.265
Normal (18.5–24.9)	17 (20.5%)	9 (10.5%)	18 (19.0%)	44 (16.7%)	
Overweight (25.0–29.9)	45 (54.2%)	45 (52.3%)	46 (48.4%)	136 (51.5%)	
Obese (≥30.0)	21 (25.3%)	32 (37.2%)	31 (32.6%)	84 (31.8%)	

Key: Continuous variables expressed as mean ± standard deviation. Categorical variables expressed as n (%). Nutrition mMDS total, total score from Modified Mediterranean Diet Score questionnaire. SF-12, Short-Form 12 Health-related Quality of Life questionnaire. Back muscular endurance assessed with the Modified Biering-Sorensen Test. Core muscular endurance assessed with the Prone Plank Test. P value represents test of differences among the groups.

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TABLE 2. Logistic and Poisson Regression Results for Primary Outcome—Lost Work Time

Comparison/Group	Logistic Regression [OR (95% CI)]	Logistic Regression *P* Value	Poisson Regression [Difference (95% CI)]	Poisson Regression *P* Value
(1) Supervised exercise vs control				
Supervised Exercise	1		1	
Control	0.451 (0.147, 1.380)	0.1627	1.148 (1.036, 1.272)	0.008
(2) Telehealth exercise vs control				
Telehealth Exercise	1		1	
Control	0.406 (0.133, 1.239)	0.1133	5.509 (4.528, 6.703)	<0.0001
(3) Telehealth exercise vs supervised exercise				
Telehealth Exercise	1		1	
Supervised Exercise	0.900 (0.251, 3.222)	0.8714	4.798 (3.904, 5.898)	<0.0001

Key: Values are lost work time in hours.
CI, confidence interval; OR, odds ratio.

constraints—out on call (16.4%), and sick leave (9.9%). Exercise adherence data are summarized in Table 3.

Overall, no significant changes were observed in any group for changes in back and core muscular endurance from baseline to 12 months. In subgroup analyses, participants from one fire department in the supervised exercise group demonstrated a 17.4% improvement ($P = 0.019$) in back muscular endurance at 12 months; no other improvements were observed. Changes in back muscular endurance was moderately correlated with the number of exercise sessions completed ($R = 0.52$, $P = 0.013$), but no such relationship was observed for core muscular endurance.

DISCUSSION

The findings of this study indicate that a worksite exercise intervention emphasizing the back and core muscles was effective in reducing lost work time related to LBP in firefighters compared to control. For participants who reported lost work time related to LBP, the telehealth exercise intervention decreased lost work time by 5-fold compared to the other intervention groups. Based on these findings, a worksite back and core exercise program, particularly when delivered by telehealth, is recommended to help attenuate lost work time related to LBP in career firefighters from departments with similar characteristics as those assessed in this study.

The difference in lost work time between telehealth and supervised exercise is contrary to the original hypothesis. One explanation for this difference is that intrapersonal, interpersonal, and administrative factors in firefighter culture influence worksite interventions in firefighters,[34,35] which may affect outcomes favoring telehealth delivery. Another explanation is that the design of the telehealth system allows for consistency, periodic and positive feedback on performance, and the ability of firefighters to complete exercises on their own time.

Another key finding of the current study is that firefighters seemingly under-reported LBP to administration, suggesting that many firefighters continued to work with symptoms. This finding was unexpected and resulted in a smaller than hypothesized sample size of firefighters reporting lost work time related to LBP. Possible explanations for the apparent under-reporting include: (1) firefighters are dedicated to their occupation and continue to work despite symptoms; (2) firefighters are apprehensive about job security and being placed on light duty status if injury is reported; and (3) the episodes of LBP observed in the current study were not catastrophic and did not result in hospitalization or surgery.

Exercise adherence observed in the current study was lower than adherence reported in a previous study on worksite back and core exercise in career firefighters.[3] One explanation for the lower than expected adherence is that the number of emergency responses increased by 20.5% over 5 years preceding enrollment among the participating departments (2012: 231,325 responses; 2017: 278,795 responses), which reduced firefighter availability. Another explanation is that the intervention period for the current study was 1 year compared to 6 months in the previous study. A third explanation is that a large seasonal hurricane passed through Florida during the latter stages of the intervention period. This natural disaster greatly increased workload, making firefighters schedules more hectic, and reducing the amount of time firefighters perceived that they had when required to remember exercise sessions in combination with all other shift activities. Consequently, it seems that supervision helped participants focus on exercise performance during these erratic times.

As expected, telehealth delivery attenuated missed sessions due to emergency responses. However, adherence dropped off dramatically in the latter stages of the intervention period compared to supervised delivery. One explanation for this finding is that the telehealth group did not have face-to-face attention and related external motivators offered to the supervised group. Lack of attention may become more problematic when an intervention is delivered over the long-term. Considering these factors, adherence in worksite exercise interventions may improve by implementing a combination of telehealth and supervised delivery approaches.

In the current study, no improvements in back and core muscular endurance were observed in the exercise groups, which contradicts previous work in firefighters.[3] However, the firefighters in the exercise groups of the current study showed improvements in the exercise progression model (ie., moved heavier loads) throughout the study period, which suggests that functional capacity and

TABLE 3. Exercise Adherence by Group and Time Point

	Group	
Time Point (Mo)	Supervised ($n = 86$)	Telehealth ($n = 95$)
1–3	61.2% ± 16.6%	66.5% ± 22.6%
4–6	46.2% ± 20.0%	44.2% ± 31.7%
7–9	41.2% ± 23.7%	33.1% ± 31.8%
10–12	32.7% ± 24.5%	21.5% ± 29.2%*
Total (1–12)	45.1% ± 17.7%	41.7% ± 24.5%

Key: Values are % exercise adherence (mean ± standard deviation). % Exercise adherence = (number of completed exercise sessions/number prescribed exercise sessions) × 100%. Number of prescribed sessions at each 3-month time period = 26. Number of prescribed sessions total = 104.
*Supervised > Telehealth, $P < 0.05$.

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physical fitness also improved. It is possible that the back and core muscular endurance tests used in the current study have ceiling effects in first responders.[36]

A strength of the current study was that a cluster randomized controlled trial was successfully completed within a complex environment. The trial enrolled 264 firefighters across 78 stations and four fire departments, and involved over 8000 exercise sessions and over 1000 assessments across numerous time points. Moreover, the data collected for the primary outcome of lost work time related to LBP were novel, requiring triangulation and verification from several sources across multiple time points, instruments, and departments. Therefore, independent of the impact of the intervention on the primary outcome, the current study's methods may be useful for informing future research and implementation efforts in firefighters and other high-risk occupations with similar settings and job demands.

The current study had limitations that need to be recognized. (1) Exercise adherence was documented by self-report for the telehealth group and direct face-to-face interaction for the supervised group. Tracking physical activity through self-report has limitations,[37] and the impact of self-report versus face-to-face confirmation of exercise adherence is unknown. (2) The study intervention groups (supervised exercise, telehealth exercise, control) had unequal attention times. While this limitation is acknowledged, the study was purposely designed as a pragmatic clinical trial in a usual work environment. (3) The primary outcome measure focused on lost work time, but other markers to assess the impact of LBP may also have been useful. However, lost work time was deemed the best approach for the current study for reasons described earlier in this manuscript. (4) Fewer participants than expected reported lost work time related to LBP, which limited the analyses. A 5-year historical analysis of LBP and lost work time, which was conducted prior to enrollment in one of the participating departments, indicated that rates and consequences of LBP and lost work time were greater during the 5 years preceding enrollment than during the 1-year study period. Nevertheless, discussions with fire service stakeholders indicated that the LBP and lost work time rates observed in study participants were similar to firefighters who did not participate over the 1-year study period. The reasons for the decline in rates during the 1-year study period compared to the preceding 5 years are unknown. (5) The health economic impact of the improvements in lost work time observed in the exercise groups is unknown. (6) The feasibility of long-term implementation of the exercise interventions throughout the fire service and other high-risk occupational settings is unknown and could be limited by operational and cost barriers.

Future research is needed to clarify the optimal implementation approaches for worksite exercise aimed at LBP prevention in firefighters. Implementation factors that could be assessed include departmental characteristics (eg, career, volunteer, urban, rural, coastal, wildland, department size), varying levels of available resources, participation incentives, and mandatory versus voluntary participation. Research is also needed to explore factors related to impact of firefighters working with LBP, as well as the apparent superiority of telehealth delivery over direct supervision. Finally, research is needed to determine the cost effectiveness, cost utility, and cost benefit of the worksite exercise interventions administered in the current study.

CONCLUSIONS

The findings of this study indicate that a worksite exercise program emphasizing the back and core muscles can reduce lost work time related to LBP in career firefighters compared to control, particularly when delivered via a telehealth system. These findings can be used to inform implementation and future research on worksite exercise programs for prevention of LBP in the fire service and other high-risk occupational settings.

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