



Physical activity, sedentary behaviour and mental health outcomes in firefighters: A cross-sectional study

Davy Vancampfort, Erik De Soir, Ruud van Winkel, Quinette Abegail Louw, Grace McKeon, Simon Rosenbaum, Soraya Seedat & Carlos Pelayo Ramos-Sanchez

To cite this article: Davy Vancampfort, Erik De Soir, Ruud van Winkel, Quinette Abegail Louw, Grace McKeon, Simon Rosenbaum, Soraya Seedat & Carlos Pelayo Ramos-Sanchez (2023): Physical activity, sedentary behaviour and mental health outcomes in firefighters: A cross-sectional study, *Journal of Workplace Behavioral Health*, DOI: [10.1080/15555240.2023.2191203](https://doi.org/10.1080/15555240.2023.2191203)

To link to this article: <https://doi.org/10.1080/15555240.2023.2191203>



Published online: 17 Mar 2023.



Submit your article to this journal [↗](#)



View related articles [↗](#)



View Crossmark data [↗](#)

RESEARCH ARTICLE



Physical activity, sedentary behaviour and mental health outcomes in firefighters: A cross-sectional study

Davy Vancampfort^{a,b} , Erik De Soir^c , Ruud van Winkel^d ,
Quinette Abigail Louw^e , Grace McKeon^f , Simon Rosenbaum^{f,g} ,
Soraya Seedat^h , and Carlos Pelayo Ramos-Sanchez^a 

^aDepartment of Rehabilitation Sciences, KU Leuven, Leuven, Belgium; ^bUniversity Psychiatric Center, KU Leuven, Leuven, Belgium; ^cDe Weg Wijzer, Center for Trauma and Griefcounseling, Hasselt, Belgium; ^dDepartment of Neurosciences, Center for Clinical Psychiatry, KU Leuven, Leuven, Belgium; ^eDepartment of Health and Rehabilitation Sciences, Physiotherapy Division, Faculty of Medicine and Health Sciences, Stellenbosch University, Cape Town, South-Africa; ^fDiscipline of Psychiatry and Mental Health, Faculty of Medicine, University of New South Wales, Sydney, Australia; ^gSchool of Health Sciences, University of New South Wales, Sydney, Australia; ^hDepartment of Psychiatry, Faculty of Medicine and Health Sciences, Stellenbosch University, Cape Town, South-Africa

ABSTRACT

This study in firefighters aims to explore correlations between physical activity (PA), sedentary levels, PTSD symptoms, psychological distress and well-being. We also compare PTSD symptoms, psychological distress and well-being in those who meet the 150 min of moderate-to-vigorous PA per week recommendation versus those who don't. Finally, we compare PA levels in those with PTSD versus without. Self-reported PA and sedentary levels [Simple Physical Activity Questionnaire, Physical Activity Vitals Sign], PTSD symptoms (PTSD Checklist for DSM-5, PCL-5), psychological distress (Kessler-6, K-6) and well-being (WHO-5 Well-being index) were collected in 87 firefighters (77 men, age = 43.1 years; SD = 10.3). Spearman Rho correlations were used to explore associations and Mann-Whitney *U* tests to examine differences between subgroups. Time spent exercising correlated with PTSD symptoms ($\rho = -0.220$; $p = 0.041$). Those with significant PTSD symptoms spent less time exercising ($U = 102.5$; $p = 0.018$) and more time sedentary ($U = 375$; $p = 0.027$). Physically inactive firefighters scored 5.4 points higher on the PCL-5, 1.5 points more on the K-6, and 5.2 points less on the WHO-5. Participants with PTSD ($n = 6$) were more sedentary ($U = 375.0$; $p = 0.027$) and exercised less ($U = 102.5$; $p = 0.018$) compared to those without. Physical inactivity and sedentary behavior could be considered in prevention and treatment programs for psychological distress and PTSD in firefighters.

ARTICLE HISTORY

Received 1 November 2022
Accepted 11 March 2023

KEYWORDS

Exercise; first responders; stress; trauma

Introduction

Firefighters are expected to be physically fit and resilient to perform strenuous duties without compromising the safety of themselves, colleagues, or the community (Bos, Mol, Visser, & Frings-Dresen, 2004). But, they are also regularly exposed to life-threatening situations and traumatic events (Berger et al., 2012). This cumulative exposure to life-threatening and traumatic events may put them at a high risk of developing serious psychological distress and could have a detrimental effect on their general well-being, increasing problematic alcohol use and worsening sleep quality, and consequently a decreasing mental health (Declercq, Meganck, Deheegher, & Van Hoorde, 2011; McKeon, Wells, Steel, Moseley, & Rosenbaum, 2021; Wagner, McFee, & Martin, 2010; Zegel, Lebeaut, Healy, Tran, & Vujanovic, 2022). In terms of mental health, posttraumatic stress disorder (PTSD) has been identified as one of the most serious negative psychological consequences of repeated exposure to trauma (Declercq et al., 2011; Fullerton, Ursano, & Wang, 2004). In firefighters, the presence of PTSD is considered an important risk factor for suicide (Stanley, Hom, & Joiner, 2016). The prevalence of PTSD among firefighters is 10% (Berger et al., 2012), which is much higher than the 4% prevalence rate observed in the general population (Koenen et al., 2017). In addition to poor mental health, firefighters also face an increased risk of poor physical health due to a number of occupational risk factors (Achmat, Leach, & Onagbiye, 2019). For example, regular exposure to high-pressure situations such as fire suppression interventions, irregular working hours, sleep deprivation and long work shifts contribute to high rates of cardiovascular disease and its risk factors, including hypertension and obesity (Chappel, Aisbett, Vincent, & Ridgers, 2016; Durand et al., 2011; Kales, Tsismenakis, Zhang, & Soteriades, 2009). In addition, despite being very physically active during interventions, firefighters are often not very active during the rest of the day and spend a lot of their time sedentary during working hours or during their leisure time. Previous research (Durand et al., 2011) indicates that less than one in four firefighters in the US are at least 45 min per week physically active, and this either at work, during leisure time or household chores or when commuting. Sedentary behavior, on its turn, can be defined as any waking behavior characterized by an energy expenditure ≤ 1.5 metabolic equivalents, while in a sitting, reclining or lying posture (Tremblay et al., 2017). Common sedentary behaviors in firefighters during on-call duties and leisure time include TV viewing, video game playing, computer use (collective termed “screen time”), and reading (Choi, Dobson, Schnall, & Garcia-Rivas, 2016). Being physically inactive and sedentary are both also important risk factors for sudden fatal cardiovascular events in this population (Clare et al., 2015; Kales, Soteriades, Christophi, & Christiani, 2007;

Martin et al., 2019). Since fire suppression is a very strenuous occupation, it can trigger sudden fatal cardiovascular events, which even account for approximately 44% of on-duty deaths (Fahy, 2005).

To the best of our knowledge, research investigating whether physical activity, including its structured form exercise, and sedentary levels are associated with mental health outcomes such as symptoms of PTSD and psychological distress on one hand and well-being on the other is absent in firefighters. Previous research in the general population demonstrated that meeting the physical activity recommendation of 150 min of moderate-to-vigorous physical activity per week is associated with higher levels of well-being and lower odds of developing PTSD, depression, and anxiety (LeardMann et al., 2011; Schuch et al., 2019; Schuch et al., 2018). Similarly, once people have developed PTSD, they often start to engage less in physical activity, which on its turn can further compromise their physical and mental well-being (Assis et al., 2008; Hoerster et al., 2019; van den Berk-Clark et al., 2018; Winning et al., 2017). When looking at sedentary levels, in the general population, more time spent sedentary during leisure and during working hours has been associated with poor mental health (Hallgren, Nguyen, Owen, Vancampfort, Smith, et al., 2020). However, data exploring associations between sedentary levels and mental health outcomes are lacking in firefighters.

In order to address the current gaps in the literature, the aim of this study was (a) to explore associations between time spent in physical activity and time spent sedentary with mental health outcomes (namely PTSD symptoms, psychological distress, and well-being) in firefighters, (b) to compare PTSD symptom severity, psychological distress and well-being levels of firefighters who meet the physical activity recommendation of 150 min of moderate-to-vigorous physical activity per week versus those who don't, and (c) to compare physical activity and sedentary levels between firefighters with versus without likely PTSD and with versus without significant psychological distress. We hypothesize that less time spent physically active during the day and more time spent sedentary are associated with poorer mental health outcomes, i.e., higher psychological distress, higher levels of PTSD, and lower overall well-being. We will focus here on time spent walking, exercising (i.e., structured physical activity such as aerobic and resistance training) (Caspersen, Powell, & Christenson, 1985), and time spent in incidental physical activity such as doing household chores. Second, we also hypothesize that meeting the physical activity recommendation of 150 min of moderate-to-vigorous physical activity per week is associated with better mental health outcomes. Finally, we hypothesize that firefighters meeting the criteria for PTSD and/or for psychological distress are less physically active and more sedentary.

Methods

Participants

Firefighters were contacted in the first place by mail through the Fire Stress Team (FiST), a nonprofit peer support network of fire rescue personnel with training in psychological support and early intervention in the wake of potentially traumatic interventions. The peer support officers of the FiST network are active firefighters who aim at increasing the awareness for psychological support and post-intervention support for first responders in Belgium. Since there is no difference in Belgium between the physical and operational requirements or training for career or volunteer firefighters and both categories have mandatory on-call (fire and ambulance) duties at the fire station (Tonnaer, 2019) during which they are recommended to engage in physical activity at least three times per week (Vlaamse Vereniging van Steden en Gemeenten, 2022), no explicit separation for both categories was made in the description of the participants' sample. Participants were recruited between December 2021 and March 2022 during the Covid-19 pandemic (during active lockdown measures) via an e-mail sent to FiST members containing a flyer of the study. Additionally, this study was promoted on FiST's web page, their social media platform, and in FiST's newsletter. FiST members were able to share the recruitment call for this study with their colleagues in the regional fire intervention zones. These e-mails and the open call for participants were repeated on three occasions. Interested participants were able to contact the research team via email to express interest. There has been no formal (financial or other) incentive for participation in this study except the announcement that in each station where a group of colleagues participated in the study, there would be the ad random appointment of someone winning a book on "crisis intervention in trauma survivors" (written by the second author of this paper). A Skype for Business meeting could be scheduled to discuss the participant information leaflet before providing online informed consent, however nobody requested such a meeting. Participants were eligible for inclusion if: (a) they were aged between 18 and 65, and (b) they were actively engaged as a firefighter. Retired firefighters, or those who had failed to complete the Simple Physical Activity Questionnaire (Rosenbaum et al., 2020) were excluded from the study. This study has been approved by the Social and Societal Ethics Committee of the KU Leuven (G-2020-2473-R2(MIN)).

Power analysis

A power analysis using G*Power (3.1.9.7) (Faul, Erdfelder, Lang, & Buchner, 2007) demonstrated that a sample size of 84 participants was

required to detect a small effect ($r=0.3$) (Cohen, 2013) with statistical power of 80% and significance level of 0.05. This power is valid for the correlation analyses; however, group comparisons were carried out on an exploratory basis.

Demographical data

Demographical data collected consisted of participants' age (years), gender (male, female, non-binary), rank, namely high (lieutenant to colonel), middle (sergeant, adjutant), or low (firefighter, corporal), and voluntary and/or professional status. In Belgium, 10,900 from 17,300 firefighters are volunteers (Belgian Dictorate-General Civil Security, 2020). The training and operational engagement of professional versus voluntary firefighters are however identical (Belgian Dictorate-General Civil Security, 2020) and the difference between professional and voluntary firefighters in terms of rank, work-related activities and experiences neglectable.

Outcome measures

Simple Physical Activity Questionnaire (SIMPAQ) (Rosenbaum et al., 2020)

The SIMPAQ (Rosenbaum et al., 2020) is a 5-item clinical tool to assess physical activity levels among populations at high risk for physical inactivity. It estimates time spent in bed (min/day), time spent sedentary during waking hours (min/day), time spent napping (min/day), time spent walking (min/day), time spent in exercise (min/day), and time spent in incidental or non-structured physical activity, like going to the supermarket or commuting (min/day), during the past week. The sum of the hours recorded in the SIMPAQ items should add to approximately 24-h. In this study, we focus on the time spent sedentary, time spent walking, time spent in structured exercise, and time spent in incidental or non-structured physical activity. The SIMPAQ has good a test-retest reliability ($\rho=0.63-0.76$) and validity ($\rho=0.25$) for assessing PA levels of patients with a mental illness diagnosis (Rosenbaum et al., 2020). For sedentary time a measure-of-proxy score obtained by subtracting time spent sleeping and the total time spent being physically active during the day from the 24h framework was more reliable and valid than the self-reported score (Rosenbaum et al., 2020), and therefore used in this study.

Physical Activity Vital Sign (PAVS) (Greenwood, Joy, & Stanford, 2010)

Meeting the physical activity guidelines was assessed using the PAVS (Greenwood et al., 2010), comprised of two simple questions

(Greenwood et al., 2010). The first question was: “On average how many days per week do you engage in moderate-to-vigorous physical activity like a brisk walk?” It was explained to participants that moderate-to-vigorous intensity refers to activity that increases breathing or heart rate more than normal. The second question was: “On those days, how many minutes do you engage on average in physical activity at this level?” Next the two responses were multiplied together to calculate the minutes per week of self-reported moderate-to-vigorous physical activity and verified whether the participants were achieving the recommended target of 150 min per week of moderate-to-vigorous physical activity or not (yes = 1; no = 0). The PAVS is a valid ($\kappa=0.55$) and reliable ($\rho=0.57$) tool for distinguishing whether people do or do not meet the World Health Organization physical activity guidelines (Ball, Joy, Gren, & Shaw, 2016).

PTSD checklist for the DSM-5 (PCL-5) (Blevins, Weathers, Davis, Witte, & Domino, 2015)

The PCL-5 (Blevins et al., 2015) is a self-report assessment tool that measures symptoms of posttraumatic stress during the past month with the aim of monitoring symptom change, screening individuals for PTSD, or making a provisional PTSD diagnosis. The PCL-5 contains 20 items that are scored on a 5-point Likert scale ranging from 0 (not at all) to 4 (extremely). This tool provides indication for PTSD and a severity score (0–80) with higher scores indicating higher severity. A cutoff of 41 is recommended for providing a provisional diagnosis of PTSD in first responders (Morrison, Su, Keck, & Beidel, 2021). The PCL-5 has good psychometric properties and is a sound measure of DSM-5 PTSD symptoms (Blevins et al., 2015). It has a strong internal consistency ($\alpha=0.94$), test-retest reliability ($r=0.82$), and validity (Blevins et al., 2015).

Kessler-6 (K-6) (Kessler et al., 2002)

The K-6 (Kessler et al., 2002) is a self-report assessment tool that measures psychological distress in the past 30 days using 6 short items on a 5-point Likert scale ranging from 1 (all of the time) to 5 (none of the time). The K-6 is also used to identify individuals with increased psychological distress drawing from depressive- and anxiety-related symptoms, with a cutoff of 13 indicating severe psychological distress (Kessler et al., 2002). The K-6 is a valid instrument which is moderately correlated ($r=0.65$) to other golden-standard assessments (Kessler et al., 2003).

The WHO-5 Well-being—index (Topp, Østergaard, Søndergaard, & Bech, 2015)

The WHO-5 Well-being—index (Topp et al., 2015) is a self-report assessment tool that measures general well-being over the past 2 weeks. It contains 5 questions rated on a 6-point Likert scale ranging from 0 (at no time) to 5 (all of the time). Higher scores indicate a better general well-being (Topp et al., 2015). The WHO-5 is a feasible tool with strong internal consistency ($\alpha = 0.923$) for assessing well-being in mental health settings (Lara-Cabrera, Mundal, & De Las Cuevas, 2020).

Statistical analysis

Normality was tested by means of the Shapiro-Wilk test and showed that none of the data were normally distributed. Non-substantial missing data were imputed automatically based on data exploration. Demographic data and differences in physical activity levels as measured with the SIMPAQ between different professional ranks were calculated. Associations between SIMPAQ scores and mental health outcomes (PCL-5, K-6, and WHO-5 total scores) were checked using the Spearman Rho coefficients.

Since age did not correlate significantly with any of the SIMPAQ scores and no gender-related differences were found, we did not correct for age or gender. To interpret the strength of correlation, we used Cohen cutoff points of 0.10, 0.30, and 0.50: with $r < 0.30$ considered as a weak correlation, $0.30 \leq r < 0.50$ as a moderate correlation, and $r \geq 0.50$ as a large correlation (Cohen, 2013). Differences in general well-being and mental health outcomes (K-6, WHO-5, PCL-5 total scores) between those who did and did not meet the minimum physical activity recommendation of at least 150 min of moderate-to-vigorous physical activity per week, and differences in sedentary and physical activity levels between those with versus without PTSD ($PCL-5 \geq 41$) and psychological distress ($K-6 \geq 13$) were investigated using Mann–Whitney *U*-test. Data are shown in means and standard deviations for easier comparison with other research, rank means, interquartile range, and cases above and beneath the median. The statistical analysis was performed with SPSS v.28.

Results

Participants

A total of 104 firefighters participated. Seventeen records had to be excluded due to substantial missing data, leaving a total of 87 participants. The majority of participants were male (89%), and the mean age was 43.1 years ($SD = 10.3$; range = 20–61). Most participants were holding a

lower rank (60.9%) with the lowest rank being regular firefighter, followed by the rank of corporal. The majority of firefighters were volunteers (51.7%). With regards to mental health outcomes, the mean PCL-5 total score was 11.4 (SD = 14.0), with 6 participants (6.9%) scoring above the cutoff for PTSD (PCL-5 \geq 41). The mean K-6 total score was 4.8 (SD = 4.0) with 5 (5.7%) scoring above the cutoff for psychological distress (K-6 \geq 13). The mean WHO-5 score was 63.9 (SD = 19.0). Regarding time spent being physically active, 27 participants (31%) did not meet World Health Organization physical activity guidelines of 150 min of moderate-to-vigorous physical activity per week as measured with the PAVS. Firefighters spent on average 51.2 min per day walking (SD = 65.9), 33.6 min per day exercising (SD = 31.5), and 168.0 min per day on incidental physical activity (SD = 175.8) as measured with the SIMPAQ. Firefighters higher in rank were the most sedentary, sitting for 14.1 h (SD = 1.6) on average per day, as well as less physically active, walking on average 40.2 min (SD = 43.7), exercising 30.2 min (SD = 24.9), and spending 60.4 min (SD = 63.2) in incidental physical activity per day, albeit differences were not significant with firefighters with other ranks. Firefighters in middle management functions spent on average 11.4 h per day being sedentary (SD = 3.2), 55.1 min (SD = 66.9) per day walking, 30.7 min (SD = 27.6) per day exercising, and 240.8 min (SD = 210.2) per day on incidental physical activity. Lastly, firefighters in basic operational functions spent on average 12.2 h (SD = 3.5) per day being sedentary, 53.1 min (SD = 72.0) per day walking, 35.7 min (SD = 34.6) per day exercising, and 169.4 min (SD = 170.3) per day on incidental physical activity. There was no difference in physical activity and sedentary levels between professional and voluntary firefighters (data not presented). An overview of the descriptive statistics can be found in [Table 1](#).

Correlations between SIMPAQ scores and mental health outcomes

Spearman correlation analyses between SIMPAQ sub-scores, PCL-5, K-6, and WHO-5 scores are presented in [Table 2](#). SIMPAQ time spent walking was not significantly correlated with any mental health-related variables, more time spent exercising as assessed with the SIMPAQ was weakly correlated with lower PCL-5 scores ($\rho = -0.220$; $p = 0.041$) and higher WHO-5 scores ($\rho = 0.245$; $p = 0.022$), and more time spent in incidental physical activity, as assessed with the SIMPAQ was weakly correlated with lower K-6 scores ($\rho = -0.227$; $p = 0.035$). There was a trend for more time spent sedentary as assessed with the SIMPAQ being weakly correlated with worse WHO-5 scores ($\rho = -0.203$; $p = 0.059$). Age and rank were not correlated with any variables.

Table 1. Descriptive statistics of the 87 included firefighters.

Variable	Mean (SD)
Age (years)	43.1 (10.3)
Male gender, <i>n</i> (%)	78 (89.7)
Rank	
Basic rank, <i>n</i> (%)	53 (60.9)
Middle rank, <i>n</i> (%)	20 (23)
Higher rank, <i>n</i> (%)	14 (16.1)
Status	
Volunteer, <i>n</i> (%)	45 (51.7)
Professional, <i>n</i> (%)	38 (43.7)
Professional and volunteer in another fire station, <i>n</i> (%)	4 (4.6)
PCL-5 total score	11.4 (14.0)
K-6 total score	4.79 (4.0)
WHO-5 total score	63.9 (18.9)
SIMPAQ	
Hours per day spent sedentary	12.4 (3.3)
Minutes per day spent walking	51.1 (65.9)
Minutes per day spent in sports or exercise	33.0 (31.5)
Minutes per day spent in incidental physical activity	168.1 (175.8)

SIMPAQ: Simple Physical Activity Questionnaire; PCL-5: PTSD Checklist for the DSM-5; K-6: Kessler-6; WHO-5: WHO well-being index-5.

Table 2. Spearman Rho correlations between SIMPAQ scores and mental health outcomes in 87 firefighters.

	PCL-5 total score		K-6 total score		WHO-5 total score	
	ρ	<i>p</i>	ρ	<i>p</i>	ρ	<i>p</i>
Walking (min/day)	0.110	0.312	-0.019	0.859	0.034	0.755
Exercising (min/day)	-0.220*	0.041	-0.113	0.295	0.245*	0.0223
Incidental physical activity (min/day)	-0.161	0.137	-0.227*	0.035	0.108	0.321
Sedentary time (h/day)	0.173	0.109	0.187	0.085	-0.203	0.059

*Significant when $p < 0.05$. SIMPAQ: Simple Physical Activity Questionnaire; PCL-5: PTSD Checklist for the DSM-5; K-6: Kessler-6; WHO-5: WHO well-being index-5.

Differences in mental health outcomes between firefighters meeting versus not meeting the recommendation of 150 min of moderate-to-vigorous physical activity per week

Firefighters who did not meet the physical activity guidelines based on the scores of the PAVS scored on average 5.4 points higher on the PCL-5, 1.5 points more on the K-6, and 5.2 points less on the WHO-5. However, these differences were not statistically significant. A detailed overview of the results of the group comparison can be found in Table 3.

Differences in physical activity and sedentary levels between firefighters with versus without PTSD (PCL-5 \geq 41) and with versus without psychological distress (K-6 \geq 13)

Participants with PTSD ($n = 6$) were more sedentary ($U = 375.0$; $p = 0.027$) and engaged in less exercise time ($U = 102.5$; $p = 0.018$) compared to those who did not meet the cutoff for likely PTSD (PCL-5 \geq 41). An overview of group differences in sedentary and physical activity levels between those

Table 3. Group differences in mental health-related variables in firefighters who met ($n = 60$) vs. did not meet ($n = 27$) physical activity guidelines^a.

	Mean (SD)	Mean rank	Interquartile range	<i>N</i> scoring lower than median	<i>N</i> scoring higher than median	<i>U</i>	<i>p</i>
PCL-5						716.0	0.387
Meeting guidelines	9.7 (11.8)	42.4	8	33	27		
Not meeting guidelines	15.2 (17.6)	47.5	19	13	14		
K-6						718.0	0.396
Meeting guidelines	4.4 (3.1)	42.5	4	36	24		
Not meeting guidelines	5.9 (5.3)	47.4	7	15	12		
WHO-5						718.0	0.396
Meeting guidelines	65.5 (22.9)	45.5	26	29	31		
Not meeting guidelines	60.3 (16.9)	40.6	12	16	11		

^aAt least 150 min per week of at least moderate intensity as assessed with the Physical Activity Vital Sign. PCL-5: PTSD Checklist for the DSM-5; K-6: Kessler-6; WHO-5: WHO well-being index-5.

who screened positive for PTSD versus those who did not can be found in Table 4. Due to the fact that only 5 participants scored above the cutoff for psychological distress and these 5 were 5 of the 6 who scored above the cutoff for PTSD, we did not perform analyses to explore differences in physical activity and sedentary levels between firefighters with versus without psychological distress.

Discussion

General findings

To the best of our knowledge, this study is the first to explore associations between time spent in physical activity and sedentary behavior and mental health outcomes such as symptoms of PTSD, psychological distress and well-being in firefighters. Our data show that time spent in structured physical activity, i.e., exercising, is associated with lower PCL-5 scores (i.e., symptoms of posttraumatic stress) and higher WHO-5 scores (i.e., well-being) in firefighters. A secondary, explorative aim was to investigate differences in PCL-5, K-6 and WHO-5 scores between those meeting versus not meeting the physical activity recommendations of the World Health Organization of 150 min of moderate-to-vigorous per week. Our data demonstrate that those meeting the recommendations scored on average 5.4 points lower on the PCL-5. Vice versa, a second explorative aim was to investigate differences in physical activity levels between those with versus without PTSD. In our study, about 7% of firefighters scored above the PCL-5 cutoff of 41 for PTSD. This is in line with previous research in US firefighters (Del Ben, Scotti, Chen, & Fortson, 2006) where a prevalence of 8% was found using a cutoff of 44 on the PCL-5 (Blevins et al., 2015). In our study, we also did find significant differences in physical activity levels

Table 4. Group differences in SIMPAQ physical activity levels and sedentary time in firefighters who met ($PCL-5 \geq 41$) ($n = 6$) vs. did not meet criteria for likely PTSD ($n = 81$).

	Mean (SD)	Mean rank	Interquartile range	N scoring lower than median	N scoring higher than median	<i>U</i>	<i>p</i>
SIMPAQ walking (min/day)						207.5	0.552
Meeting PTSD criteria	32.2 (28.8)	44.4	52	4	2		
Not meeting PTSD criteria	52.5 (67.8)	38.1	46	40	41		
SIMPAQ exercising (min/day)						102.5	0.018*
Meeting PTSD criteria	8.7 (6.1)	20.6	11	6	0		
Not meeting PTSD criteria	34.8 (31.9)	45.7	38	40	41		
SIMPAQ incidental PA (min/day)						188.5	0.358
Meeting PTSD criteria	102.0 (94.7)	34.9	172	4	2		
Not meeting PTSD criteria	173.0 (179.8)	44.7	180	55	26		
SIMPAQ sedentary time (h/day)						375.0	0.027*
Meeting PTSD criteria	14.9 (1.7)	66.0	3	1	5		
Not meeting PTSD criteria	12.2 (3.4)	42.4	4	43	38		

*Significant when $p < 0.05$; PCL-5: PTSD Checklist for the DSM-5; SIMPAQ: Simple Physical Activity Questionnaire.

between those scoring equal to or above the cutoff of 41 on the PCL-5 (Blevins et al., 2015). More in detail, those who scored above the cutoff walked on average 20 min less per day, exercised on average 26 min less per day, and engaged on average 70 min less per day in incidental physical activity. Our finding that time spent in exercise is related to the presence of PTSD and vice versa is in line with previous longitudinal research in the general population (Whitworth, SantaBarbara, et al., 2017) and in military veterans (Whitworth & Ciccolo, 2016). Our finding also supports the cross-stressor adaptation hypothesis stating that exercise of sufficient intensity causes habituation to the physical stressors of exercise (Sothmann et al., 1996). This may ultimately lead to an adaptation in the stress response system, and a reduction in negative cognitive appraisals in response to a stressor, such as for example a reduction in avoidance and hyperarousal symptoms (Whitworth, Craft, Dunsiger, & Ciccolo, 2017). For instance, firefighters exercising during their leisure time could become more aware of the physiological responses of physical activity during these self-selected, often enjoyable and/or rewarding activities and not attribute these signs solely to their occupational activities which are very often related to high levels of stress. Due to the cross-sectional nature of our study, causality can however not be explored. Our data could imply that firefighters who engage in less physical activity are more vulnerable to PTSD, or vice versa that PTSD symptoms are a barrier for physical activity engagement in firefighters. Longitudinal and intervention studies should investigate in more detail whether, for example, increasing overall physical activity levels, could lead to less PTSD symptoms in firefighters and/or whether presence of PTSD in firefighters results in being less physically active. These studies should take into account factors that were not considered in this study and which might interfere with physical activity participation, such as levels of

alcohol consumption, high caloric snacking, and smoking (Escarfulleri, Ellickson-Larew, Fein-Schaffer, Mitchell, & Wolf, 2021; Radomski & Read, 2016; Short, Raines, Oglesby, Zvolensky, & Schmidt, 2014), or policies facilitating healthy habits, i.e., regarding exercise and fitness levels, and healthy food provision in the fire stations (Long, Readdy, & Raabe, 2014). A 2021 pilot study exploring a 10-week web-based lifestyle physical activity program delivered via a private Facebook group in Australian first responders who were physically inactive did reveal significant reductions in psychological distress during the intervention in addition to significant improvements in quality of life (McKeon, Steel, et al., 2021). These data should be confirmed specifically in firefighter settings. Related to associations between sedentary behavior and mental health outcomes in firefighters, we found that more time spent sedentary was weakly correlated with lower general well-being. Furthermore, we found that those with likely PTSD are on average 3 h more sedentary when compared to those not meeting the cutoff for PTSD. These findings are of importance since very recent evidence in the general population demonstrates that replacing 60 min of sedentary behavior with light physical activity and moderate-to-vigorous physical activity is associated with a lower odds of possible depression by 0.95 (95% CI, 0.94–0.96) and 0.75 (95% CI, 0.74–0.76), respectively, while replacing 60 min of sedentary behavior with moderate-to-vigorous physical activity is associated with a lower odds of developing an anxiety disorder by 0.90 (95% CI, 0.89–0.90) (Kandola et al., 2021). Future research should however explore in more detail associations between different types of sedentary behavior and mental health outcomes in firefighters. Previous research has demonstrated that mentally active sedentary behavior such as office work is associated with a lower risk for depression, while mentally passive sedentary behavior such as watching television is associated with a higher risk (Hallgren, Nguyen, Owen, Stubbs, et al., 2020). Similarly, future research should also explore in more detail differences in sedentary time during leisure-time versus during occupational duties. Previous research in the general population showed that compared to those reporting that they were 'almost never' sedentary in leisure-time contexts, a detrimental dose-response with frequent depression/anxiety symptoms was observed with increasing proportions of sedentary time, i.e., 50% of the time (OR = 1.44; 1.23–1.70), 75% (OR = 2.95; 2.45–3.54), almost always (OR = 3.85; 2.84–5.22) (Hallgren, Nguyen, Owen, Vancampfort, Dunstan, et al., 2020). For occupational sedentary behavior, the only associations were among those who reported being sedentary almost always, compared to almost never (OR = 1.47; 1.25–1.73) (Hallgren et al., 2020). Such studies in firefighters will be useful in order to be able to formulate specific recommendations for informing policies that affect this population.

Limitations

The results of our study should be interpreted with caution due to some limitations. First, the small number of participants who met cutoff for PTSD and distress prevented us from making firm recommendations, although these analyses were exploratory and prevalence rates were in line with a previous study in US firefighters (Del Ben et al., 2006). However, scores from the WHO-5 indicate our population is overall doing pretty well and a selection bias cannot be excluded. One should consider participants were in the first place invited via a nonprofit peer support network of fire rescue personnel with training in psychological support and early intervention in the wake of potentially traumatic interventions, i.e., FiST. FiST members were able to share the recruitment call for this study with their colleagues in the regional fire intervention zones. It might be hypothesized that the inclusion of mainly peer support officers who are in a relatively good psychological condition may have influenced the results while those feeling worse did not participate. Second, the construct validity of the SIMPAQ and PAVS is still unknown in firefighters, although the SIMPAQ has been used before in first responders (McKeon, Steel, et al., 2021). Previous research (Kling, Santiago, Benitez, Schaefer Solle, & Caban-Martinez, 2020) demonstrated that compared to objective assessments, firefighters tend to overestimate their physical activity levels, so future research could benefit of more rigorous objective measurements of physical activity. Third, due to the cross-sectional nature of this study, causal relationships cannot be established. Fourth, the online recruitment pathway may have resulted in a biased sample toward firefighters who engage with social media and are technologically literate. Fifth, also recruitment during the Covid-19 pandemic and during active lockdown measures, could have affected the results since it is known the mental health burden and sedentary levels were higher in Belgium during this period, while physical activity levels lower (Bruggeman et al., 2022; Constandt et al., 2020). Finally, there is a clear female underrepresentation in our sample. This is common in fire rescue, but there have been recent calls (Pebolle & Hall, 2019) for research examining the relationships between PTSD, exercise, and gender. Notwithstanding these limitations, this is the first study examining the relations between physical activity, sedentary time and mental health in firefighters.

Conclusions

Our findings demonstrate that more time spent exercising is associated with better mental health scores in firefighters. Results of this study suggest that firefighters with psychological distress are more sedentary and less physically active than those without psychological distress. Future longitudinal studies should confirm these findings and intervention studies should

in particular focus on the effectiveness of providing opportunities to exercise, for example during leisure time.

Acknowledgements

The authors would like to thank the participating firefighters.

Author contributions

All authors contributed to the study's conception and design. Material preparation, data collection and analysis were performed by Davy Vancampfort, Erik De Soir and Carlos Pelayo Ramos-Sanchez. The first draft of the manuscript was written by Davy Vancampfort and Carlos Pelayo Ramos-Sanchez and all authors commented on previous versions of the manuscript. All authors read and approved the final manuscript.

Disclosure statement

No potential conflict of interest was reported by the author(s).

Funding

This work is funded by Global Minds KU Leuven [Reference nr.: GPSU/20/037].

ORCID

Davy Vancampfort  <http://orcid.org/0000-0002-4592-8625>

Erik De Soir  <http://orcid.org/0000-0002-0770-1614>

Ruud van Winkel  <http://orcid.org/0000-0001-6262-1935>

Quinette Abegail Louw  <http://orcid.org/0000-0003-0238-0943>

Grace McKeon  <http://orcid.org/0000-0003-4722-1639>

Simon Rosenbaum  <http://orcid.org/0000-0002-8984-4941>

Soraya Seedat  <http://orcid.org/0000-0002-5118-786X>

Carlos Pelayo Ramos-Sanchez  <http://orcid.org/0000-0001-9144-5942>

Data availability statement

The dataset supporting the results and conclusions can be consulted upon reasonable request via email to the corresponding author.

References

- Achmat, G., Leach, L., & Onagbiye, S. O. (2019). Prevalence of the risk factors for cardio-metabolic disease among firefighters in the Western Cape province of South Africa. *The Journal of Sports Medicine and Physical Fitness*, 59(9), 1577–1583. doi:10.23736/S0022-4707.19.09137-0

- Assis, M. A. d., Mello, M. F. d., Scorza, F. A., Cadrobbi, M. P., Schooedl, A. F., Silva, S. G. d., ... Arida, R. M. (2008). Evaluation of physical activity habits in patients with posttraumatic stress disorder. *Clinics*, 63(4), 473–478. doi:10.1590/S1807-59322008000400010
- Ball, T. J., Joy, E. A., Gren, L. H., & Shaw, J. M. (2016). Peer reviewed: Concurrent validity of a self-reported physical activity “Vital Sign” questionnaire with adult primary care patients. *Preventing Chronic Disease*, 13, E16. doi:10.5888/pcd13.150228
- Belgian Dictorate-General Civil Security (2020). *Statistics Belgian Fire Departments 2020*. Brussels, Belgium: Federal Public Service Home Affairs: Belgian Directorate-General Civil Security?
- Berger, W., Coutinho, E. S. F., Figueira, I., Marques-Portella, C., Luz, M. P., Neylan, T. C., ... Mendlowicz, M. V. (2012). Rescuers at risk: A systematic review and meta-regression analysis of the worldwide current prevalence and correlates of PTSD in rescue workers. *Social Psychiatry and Psychiatric Epidemiology*, 47(6), 1001–1011. doi:10.1007/s00127-011-0408-2
- Blevins, C. A., Weathers, F. W., Davis, M. T., Witte, T. K., & Domino, J. L. (2015). The posttraumatic stress disorder checklist for DSM-5 (PCL-5): Development and initial psychometric evaluation. *Journal of Traumatic Stress*, 28(6), 489–498. doi:10.1002/jts.22059
- Bos, J., Mol, E., Visser, B., & Frings-Dresen, M. H. (2004). The physical demands upon (Dutch) fire-fighters in relation to the maximum acceptable energetic workload. *Ergonomics*, 47(4), 446–460. doi:10.1080/00140130310001643283
- Bruggeman, H., Smith, P., Berete, F., Demarest, S., Hermans, L., Braekman, E., ... Gisle, L. (2022). Anxiety and depression in Belgium during the first 15 months of the COVID-19 pandemic: A longitudinal study. *Behavioral Sciences*, 12(5), 141. doi:10.3390/bs12050141
- Caspersen, C. J., Powell, K. E., & Christenson, G. M. (1985). Physical activity, exercise, and physical fitness: Definitions and distinctions for health-related research. *Public Health Reports*, 100(2), 126.
- Chappel, S. E., Aisbett, B., Vincent, G. E., & Ridgers, N. D. (2016). Firefighters’ physical activity across multiple shifts of planned burn work. *International Journal of Environmental Research and Public Health*, 13(10), 973. doi:10.3390/ijerph13100973
- Choi, B., Dobson, M., Schnall, P., & Garcia-Rivas, J. (2016). 24-Hour work shifts, sedentary work, and obesity in male firefighters. *American Journal of Industrial Medicine*, 59(6), 486–500. doi:10.1002/ajim.22572
- Clare, C., Au, C. T., Lee, F. Y., So, R. C., Wong, J. P., Mak, G. Y., ... McManus, A. M. (2015). Association between leisure time physical activity, cardiopulmonary fitness, cardiovascular risk factors, and cardiovascular workload at work in firefighters. *Safety and Health at Work*, 6(3), 192–199.
- Cohen, J. (2013). *Statistical power analysis for the behavioral sciences*. Routledge: London.
- Constandt, B., Thibaut, E., De Bosscher, V., Scheerder, J., Ricour, M., & Willem, A. (2020). Exercising in times of lockdown: An analysis of the impact of COVID-19 on levels and patterns of exercise among adults in Belgium. *International Journal of Environmental Research and Public Health*, 17(11), 4144. doi:10.3390/ijerph17114144
- Declercq, F., Meganck, R., Deheegher, J., & Van Hoorde, H. (2011). Frequency of and subjective response to critical incidents in the prediction of PTSD in emergency personnel. *Journal of Traumatic Stress*, 24(1), 133–136. doi:10.1002/jts.20609
- Del Ben, K. S., Scotti, J. R., Chen, Y.-C., & Fortson, B. L. (2006). Prevalence of posttraumatic stress disorder symptoms in firefighters. *Work & Stress*, 20(1), 37–48. doi:10.1080/02678370600679512
- Durand, G., Tsismenakis, A. J., Jahnke, S. A., Baur, D. M., Christophi, C. A., & Kales, S. N. (2011). Firefighters’ physical activity: Relation to fitness and cardiovascular

- disease risk. *Medicine & Science in Sports & Exercise*, 43(9), 1752–1759. doi:[10.1249/MSS.0b013e318215cf25](https://doi.org/10.1249/MSS.0b013e318215cf25)
- Escarfulleri, S., Ellickson-Larew, S., Fein-Schaffer, D., Mitchell, K. S., & Wolf, E. J. (2021). Emotion regulation and the association between PTSD, diet, and exercise: A longitudinal evaluation among US military veterans. *European Journal of Psychotraumatology*, 12(1), 1895515. doi:[10.1080/20008198.2021.1895515](https://doi.org/10.1080/20008198.2021.1895515)
- Fahy, R. F. (2005). *US firefighter fatalities due to sudden cardiac death, 1995-2004*. National Fire Protection Association Quincy, MA.
- Faul, F., Erdfelder, E., Lang, A.-G., & Buchner, A. (2007). G* Power 3: A flexible statistical power analysis program for the social, behavioral, and biomedical sciences. *Behavior Research Methods*, 39(2), 175–191. doi:[10.3758/BF03193146](https://doi.org/10.3758/BF03193146)
- Fullerton, C. S., Ursano, R. J., & Wang, L. (2004). Acute stress disorder, posttraumatic stress disorder, and depression in disaster or rescue workers. *The American Journal of Psychiatry*, 161(8), 1370–1376. doi:[10.1176/appi.ajp.161.8.1370](https://doi.org/10.1176/appi.ajp.161.8.1370)
- Greenwood, J. L., Joy, E. A., & Stanford, J. B. (2010). The physical activity vital sign: A primary care tool to guide counseling for obesity. *Journal of Physical Activity and Health*, 7(5), 571–576. doi:[10.1123/jpah.7.5.571](https://doi.org/10.1123/jpah.7.5.571)
- Hallgren, M., Nguyen, T.-T.-D., Owen, N., Stubbs, B., Vancampfort, D., Lundin, A., ... Lagerros, Y. T. (2020). Cross-sectional and prospective relationships of passive and mentally active sedentary behaviours and physical activity with depression. *The British Journal of Psychiatry*, 217(2), 413–419. doi:[10.1192/bjp.2019.60](https://doi.org/10.1192/bjp.2019.60)
- Hallgren, M., Nguyen, T.-T.-D., Owen, N., Vancampfort, D., Smith, L., Dunstan, D. W., ... Ekblom-Bak, E. (2020). Associations of interruptions to leisure-time sedentary behaviour with symptoms of depression and anxiety. *Translational Psychiatry*, 10(1), 1–8. doi:[10.1038/s41398-020-0810-1](https://doi.org/10.1038/s41398-020-0810-1)
- Hallgren, M., Nguyen, T.-T.-D., Owen, N., Vancampfort, D., Dunstan, D. W., Wallin, P., ... Ekblom-Bak, E. (2020). Associations of sedentary behavior in leisure and occupational contexts with symptoms of depression and anxiety. *Preventive Medicine*, 133, 106021. doi:[10.1016/j.ypmed.2020.106021](https://doi.org/10.1016/j.ypmed.2020.106021)
- Hoerster, K. D., Campbell, S., Dolan, M., Stappenbeck, C. A., Yard, S., Simpson, T., & Nelson, K. M. (2019). PTSD is associated with poor health behavior and greater Body Mass Index through depression, increasing cardiovascular disease and diabetes risk among US veterans. *Preventive Medicine Reports*, 15, 100930. doi:[10.1016/j.pmedr.2019.100930](https://doi.org/10.1016/j.pmedr.2019.100930)
- Kales, S. N., Soteriades, E. S., Christophi, C. A., & Christiani, D. C. (2007). Emergency duties and deaths from heart disease among firefighters in the United States. *The New England Journal of Medicine*, 356(12), 1207–1215.
- Kales, S. N., Tsismenakis, A. J., Zhang, C., & Soteriades, E. S. (2009). Blood pressure in firefighters, police officers, and other emergency responders. *American Journal of Hypertension*, 22(1), 11–20. doi:[10.1038/ajh.2008.296](https://doi.org/10.1038/ajh.2008.296)
- Kandola, A., del Pozo Cruz, B., Osborn, D., Stubbs, B., Choi, K., & Hayes, J. (2021). Impact of replacing sedentary behaviour with other movement behaviours on depression and anxiety symptoms: A prospective cohort study in the UK Biobank. *BMC Medicine*, 19(1), 1–12. doi:[10.1186/s12916-021-02007-3](https://doi.org/10.1186/s12916-021-02007-3)
- Kessler, R. C., Andrews, G., Colpe, L. J., Hiripi, E., Mroczek, D. K., Normand, S.-L., ... Zaslavsky, A. M. (2002). Short screening scales to monitor population prevalences and trends in non-specific psychological distress. *Psychological Medicine*, 32(6), 959–976. doi:[10.1017/S0033291702006074](https://doi.org/10.1017/S0033291702006074)

- Kessler, R. C., Barker, P. R., Colpe, L. J., Epstein, J. F., Gfroerer, J. C., Hiripi, E., ... Walters, E. E. (2003). Screening for serious mental illness in the general population. *Archives of General Psychiatry*, *60*(2), 184–189. doi:[10.1001/archpsyc.60.2.184](https://doi.org/10.1001/archpsyc.60.2.184)
- Kling, H., Santiago, K., Benitez, L., Schaefer Solle, N., & Caban-Martinez, A. J. (2020). Characterizing Objective and Self-Reported Levels of Physical Activity Among Florida Firefighters Across Weight Status Category: A Cross-Sectional Pilot Study. *Workplace Health & Safety*, *68*(11), 513–518.
- Koenen, K., Ratanatharathorn, A., Ng, L., McLaughlin, K., Bromet, E., Stein, D., ... Scott, K. (2017). Posttraumatic stress disorder in the world mental health surveys. *Psychological Medicine*, *47*(13), 2260–2274. doi:[10.1017/S0033291717000708](https://doi.org/10.1017/S0033291717000708)
- Lara-Cabrera, M. L., Mundal, I. P., & De Las Cuevas, C. (2020). Patient-reported well-being: Psychometric properties of the world health organization well-being index in specialised community mental health settings. *Psychiatry Research*, *291*, 113268. doi:[10.1016/j.psychres.2020.113268](https://doi.org/10.1016/j.psychres.2020.113268)
- LeardMann, C. A., Kelton, M. L., Smith, B., Littman, A. J., Boyko, E. J., Wells, T. S., ... Team, M. C. S. (2011). Prospectively assessed posttraumatic stress disorder and associated physical activity. *Public Health Reports*, *126*(3), 371–383. doi:[10.1177/003335491112600311](https://doi.org/10.1177/003335491112600311)
- Long, N., Readdy, T., & Raabe, J. (2014). What motivates firefighters to exercise? A mixed-methods investigation of self-determination theory constructs and exercise behavior. *Sport, Exercise, and Performance Psychology*, *3*(3), 203–218. doi:[10.1037/spy0000012](https://doi.org/10.1037/spy0000012)
- Martin, Z. T., Schlaff, R. A., Hemenway, J. K., Coulter, J. R., Knous, J. L., Lowry, J. E., & Ode, J. J. (2019). Cardiovascular disease risk factors and physical fitness in volunteer firefighters. *International Journal of Exercise Science*, *12*(2), 764.
- McKeon, G., Steel, Z., Wells, R., Newby, J., Hadzi-Pavlovic, D., Vancampfort, D., & Rosenbaum, S. (2021). A mental health-informed physical activity intervention for first responders and their partners delivered using facebook: Mixed methods pilot study. *JMIR Formative Research*, *5*(4), e23432. doi:[10.2196/23432](https://doi.org/10.2196/23432)
- McKeon, G., Wells, R., Steel, Z., Moseley, V., & Rosenbaum, S. (2021). Self-Reported physical and mental health of informal caregivers of emergency service workers. *Journal of Loss and Trauma*, *26*(6), 507–518. doi:[10.1080/15325024.2020.1845020](https://doi.org/10.1080/15325024.2020.1845020)
- Morrison, K., Su, S., Keck, M., & Beidel, D. C. (2021). Psychometric properties of the PCL-5 in a sample of first responders. *Journal of Anxiety Disorders*, *77*, 102339. doi:[10.1016/j.janxdis.2020.102339](https://doi.org/10.1016/j.janxdis.2020.102339)
- Pebole, M. M., & Hall, K. S. (2019). Physical activity promotion in women with PTSD: What we need for progress. *Psychology of Sport and Exercise*, *41*, 127–129.
- Radomski, S. A., & Read, J. P. (2016). Mechanistic role of emotion regulation in the PTSD and alcohol association. *Traumatology*, *22*(2), 113–121. doi:[10.1037/trm0000068](https://doi.org/10.1037/trm0000068)
- Rosenbaum, S., Morell, R., Abdel-Baki, A., Ahmadpanah, M., Anilkumar, T. V., Baie, L., ... Brand, S. (2020). Assessing physical activity in people with mental illness: 23-country reliability and validity of the simple physical activity questionnaire (SIMPAQ). *BMC Psychiatry*, *20*(1), 1–12. doi:[10.1186/s12888-020-2473-0](https://doi.org/10.1186/s12888-020-2473-0)
- Schuch, F. B., Stubbs, B., Meyer, J., Heissel, A., Zech, P., Vancampfort, D., ... Ward, P. B. (2019). Physical activity protects from incident anxiety: A meta-analysis of prospective cohort studies. *Depression and Anxiety*, *36*(9), 846–858. doi:[10.1002/da.22915](https://doi.org/10.1002/da.22915)
- Schuch, F. B., Vancampfort, D., Firth, J., Rosenbaum, S., Ward, P. B., Silva, E. S., ... Deslandes, A. C. (2018). Physical activity and incident depression: A meta-analysis of prospective cohort studies. *American Journal of Psychiatry*, *175*(7), 631–648. doi:[10.1176/appi.ajp.2018.17111194](https://doi.org/10.1176/appi.ajp.2018.17111194)

- Short, N. A., Raines, A. M., Oglesby, M. E., Zvolensky, M. J., & Schmidt, N. B. (2014). Insomnia and emotion dysregulation: Independent and interactive associations with posttraumatic stress symptoms among trauma-exposed smokers. *Journal of Affective Disorders*, 165, 159–165. doi:10.1016/j.jad.2014.04.069
- Sothmann, M. S., Buckworth, J., Claytor, R. P., Cox, R. H., White-Welkley, J. E., & Dishman, R. K. (1996). Exercise training and the cross-stressor adaptation hypothesis. *Exercise and Sport Sciences Reviews*, 24(1), 267–287.
- Stanley, I. H., Hom, M. A., & Joiner, T. E. (2016). A systematic review of suicidal thoughts and behaviors among police officers, firefighters, EMTs, and paramedics. *Clinical Psychology Review*, 44, 25–44. doi:10.1016/j.cpr.2015.12.002
- Tonnaer, C. (2019). *Legal status of (on-call) volunteer firefighters in Europe*. Zoetermeer: Instituut Fysieke Veiligheid.
- Topp, C. W., Østergaard, S. D., Søndergaard, S., & Bech, P. (2015). The WHO-5 Well-Being Index: A systematic review of the literature. *Psychotherapy and Psychosomatics*, 84(3), 167–176. doi:10.1159/000376585
- Tremblay, M. S., Aubert, S., Barnes, J. D., Saunders, T. J., Carson, V., Latimer-Cheung, A. E., ... Chinapaw, M. J. (2017). Sedentary behavior research network (SBRN)–terminology consensus project process and outcome. *International Journal of Behavioral Nutrition and Physical Activity*, 14(1), 1–17. doi:10.1186/s12966-017-0525-8
- van den Berk-Clark, C., Secrest, S., Walls, J., Hallberg, E., Lustman, P. J., Schneider, F. D., & Scherrer, J. F. (2018). Association between posttraumatic stress disorder and lack of exercise, poor diet, obesity, and co-occurring smoking: A systematic review and meta-analysis. *Health Psychology*, 37(5), 407–416. doi:10.1037/hea0000593
- Vlaamse Vereniging van Steden en Gemeenten. (2022). *Gids voor de opstart van een conditiebeleid binnen een hulpverleningszone*. Brussels: Vlaamse Vereniging van Steden en Gemeenten.
- Wagner, S. L., McFee, J. A., & Martin, C. A. (2010). Mental health implications of fire service membership. *Traumatology*, 16(2), 26–32. doi:10.1177/1534765610362803
- Whitworth, J. W., & Ciccolo, J. T. (2016). Exercise and post-traumatic stress disorder in military veterans: A systematic review. *Military Medicine*, 181(9), 953–960. doi:10.7205/MILMED-D-15-00488
- Whitworth, J. W., Craft, L. L., Dunsiger, S. I., & Ciccolo, J. T. (2017). Direct and indirect effects of exercise on posttraumatic stress disorder symptoms: A longitudinal study. *General Hospital Psychiatry*, 49, 56–62. doi:10.1016/j.genhosppsych.2017.06.012
- Whitworth, J. W., SantaBarbara, N. J., Nosrat, S., LaBrec, J. E., Louie, M. E., & Ciccolo, J. T. (2017). Exercise behavior and gender-related differences in posttraumatic stress disorder symptoms. *Psychology of Sport and Exercise*, 33, 18–23. doi:10.1016/j.psychsport.2017.07.008
- Winning, A., Gilsanz, P., Koenen, K. C., Roberts, A. L., Chen, Q., Sumner, J. A., ... Kubzansky, L. D. (2017). Post-traumatic stress disorder and 20-year physical activity trends among women. *American Journal of Preventive Medicine*, 52(6), 753–760. doi:10.1016/j.amepre.2017.01.040
- Zegel, M., Lebeaut, A., Healy, N., Tran, J. K., & Vujanovic, A. A. (2022). Mental health correlates of probable posttraumatic stress disorder, probable alcohol use disorder, and their co-occurrence among firefighters. *Behavior Modification*, 46(2), 395–421. doi:10.1177/01454455211033517

