Prins PJ, Goss FL, Welton GL, Robertson RJ, & Hostler D. Observer estimation of OMNI scale RPE during a firefighter skills test using video-graphic analysis
J Sport Human Perf 2017; 5(2):1-11.

JSHP
JOURNAL OF SPORT AND HUMAN PERFORMANCE

ORIGINAL RESEARCH OPEN ACCESS

OBSERVER ESTIMATION OF OMNI SCALE RPE DURING A FIREFIGHTER SKILLS TEST USING VIDEO-GRAPHIC ANALYSIS

Prins PJ[1], Goss FL[2], Welton GL[3], Robertson RJ[2], Hostler D[4]

[1] *Department of Exercise Science, Grove City College, PA, USA*
[2] *Center for Exercise and Health-Fitness Research, University of Pittsburgh, PA, USA*
[3] *Department of Psychology, Grove City College, PA, USA*
[4] *Emergency Responder Human Performance Lab, Department of Exercise and Nutrition Sciences, SUNY University at Buffalo, NY, USA*

Correspondence to: Philip J. Prins, Ph.D
100 Campus Drive
Grove City, PA, USA, 16127
pjprins@gcc.edu:

ABSTRACT

INTRODUCTION: During fire suppression, observations of the effort, strain, discomfort, and fatigue experienced by a firefighter may be helpful to identify firefighters that need a rest period, since obtaining a self-reported estimate of ratings perceived exertion (RPE) is often not practical. Therefore, exertional observations could provide subjective information that may reduce the risk of injury by identifying individuals who are fatigued. **PURPOSE**: To assess: 1) reliability of a kinematic video-graphic observational analysis procedure; and 2) validity of a kinematic video-graphic observation analysis procedure compared to self-reported RPE. **METHODS:** Fifty-four male and female college aged students (28 men, 26 women; age 21.2 ± 2 yr.; weight 69.79 ± 11.36 kg; height 177.88 ± 9.22 cm) were asked to estimate the perceived exertion (RPE) of twenty certified firefighters (age 29.1 ± 7.0 yr.; weight 90.9 ± 19.4 kg; height 69.7 ± 3.4 cm) during a firefighter skills test using direct kinematic video-graphic analysis. Observers estimated RPE at six different epochs: immediately before exercise (IBE), top of stairs (TOS), bottom of stairs (BOS), immediately after hose drag (IAHD), immediately after exercise (IAE), and session (S). RPE was self-reported by firefighters IBE and IAE. **RESULTS:** Observer RPE estimates were significantly lower than the self-reported ratings ($p < .001$; mean difference: 0.54 ± 0.84). Observer ratings demonstrated strong interrater reliability (intraclass correlation coefficients ranging from 0.989 to 0.995, $p < .001$). **DISCUSSION:** These findings indicate that the observational technique employed presently could possibly be used to provide estimates of exertional perceptions in firefighters, however more research is warranted to further validate kinematic observation in firefighters.

Keywords: Perceived exertion, firefighters, observational technique

INTRODUCTION

Ratings of perceived exertion (RPE) are frequently obtained during a wide array of physical activities conducted in field settings (Noble & Robertson, 1996). This psychophysiological measure is defined as ‘‘a subjective intensity of effort, strain, discomfort, and/or fatigue experienced during exercising’’ (Robertson et al., 1998). Numerous indicators of physical activity are measured in a laboratory setting, including: intensity, speed, power output, heart rate, and oxygen consumption. However, in real life settings, the objective assessment of exercise intensity is usually restricted by the lack of equipment, time, and/or qualified personnel. An alternative non-laboratory measurement procedure to assess intensity of free-form activities involves exertional observation. Exertional observation is simple and low-cost and has low subject burden (Robertson et al., 2006). Observed RPE is measured using a perceived exertion scale having numerical categories and related verbal descriptors.

Exertional observation is grounded in behavioral observation and visual perception. This technique usually involves an independent observer estimating the effort, strain, discomfort and/or fatigue that an individual experiences during exercise. There have been few investigations that have examined exertional observation kinematics. In research by Ljunggren (1986) and Holzmann (1982), RPE was estimated by an observer in adult male and female subjects who performed intermittent aerobic and weightlifting exercise tests respectively, by using adult formatted category perceived exertion scales. The observer’s and subject’s RPE were highly correlated in both of these investigations.

Research by Johanssen (1973) identified the basic assumptions underlying visual exertional kinematics. The assumptions are that an observer should be able to identify individual movement patterns (i.e., walk, run, jump, etc.), detect slight deviation from normal movement that may indicate changes in exertion, distinguish between non-fatiguing and fatiguing actions, and lastly recognize exertional signs and symptoms.

Exertional observational assessment may be valuable in work-related activities where participants are performing tasks during which stopping to rate perceived exertion is difficult and impractical, for example during firefighting (Goss et al., 2014). Firefighting is an inherently dangerous occupation. According to a report from The National Fire Protection Association there were an estimated 1,103,300 firefighters in the United States in 2010 (Karter & Stein, 2011). The average rate of fatal workplace injuries to firefighters in the United States was 4.15 times higher than the 4 per 100,000 rate for all workers in 2006 (U.S. Department of Labor, 2006). In 2013, 65,880 injuries were reported in firefighters performing occupational duties. The leading cause of fire ground injuries was “overexertion/strain” (55.3%) (Karter & Molis, 2014). During fire suppression, the use of kinematic observational procedures to quantify effort, strain, discomfort, and fatigue experienced by a firefighter may be useful to detect firefighters that need a rest period. This is because obtaining a self-reported estimate of RPE is often not practical under such demanding functional conditions as encountered during fire suppression. Therefore, subjective information attained from exertional observations may reduce the risk of injury by recognizing individuals who are at risk for fatigued related injury (Goss et

al. 2014). In addition, since firefighters usually work as teams, an excessively fatigued individual may jeopardize the safety of other team members (Goss et al. 2014). Exertional observations could therefore identify those selected individuals with high levels of exertion/acute fatigue while performing fire suppression who are in need of support. (Colburn et al., 2011). It is not known whether the use of a kinematic video-graphic observational analysis technique to estimate RPE of firefighters during a skills test that simulates critical fire suppression activities is a valid and reliable technique. Therefore, the purpose of the present investigation was to explore the validity of a kinematic video-graphic observation analysis procedure compared to self-reported RPE. In addition, the reliability of a direct kinematic video-graphic observation analysis procedure was examined. The primary hypothesis was that the self-reported ratings of perceived exertion obtained immediately before and after a fire suppression training session would not differ from the estimate obtained using video-graphic observational procedures by moderately trained observers. Furthermore, we hypothesized that observer estimates of perceived exertion would not differ between experimental trials.

METHODS

Design

This study employed a randomized, cross-sectional, perceptual observation design to assess exertional perceptions of firefighters performing a timed skills test. Observers performed two video-graphic observational procedures separated by seven days. Each observer completed three days reviewing videos of firefighters performing a standardized skills test: 1) Orientation session; 2) Observational Trial I; 3) Observational Trial II. During the first testing session, high and low perceptual anchors were established for the OMNI Perceived Exertion Scale using standard procedures (Robertson, 2004). Additionally, observers were familiarized with the video-graphic observation procedure. During the observation trials observers were asked to estimate the perceived exertion of twenty certified firefighters (age 29.1 ± 7.0 yr.; weight 90.9 ± 19.4 kg; height 69.7 ± 3.4 cm) at six different epochs of a firefighter fitness test utilizing a video-graphic procedure. Observer exertional estimates were compared to the self-reported ratings of perceived exertion. Observer estimates were also compared between experimental trials.

Participants

Fifty-four male and female college aged students (28 men, 26 women; age 21.2 ± 2 yr.; weight 69.79 ± 11.36 kg; height 177.88 ± 9.22 cm) recruited from undergraduate exercise science classes volunteered to participate in this study. From this point forward subjects are referred to as "observers". Risks and benefits of participation were presented to each participant and written informed consent was obtained. The experimental protocol was approved by the Institutional Review Board of the University of Pittsburgh.

Procedures

Firefighter Skills Test

Throughout the test each firefighter wore his own department-issued thermal protective clothing that consisted of heavy pants and coat, steel-toed boots, gloves, polycarbonate helmet, Nomex hood, and a

self-contained breathing apparatus. Firefighters wore a breathing apparatus mask that concealed the entire face during the test. Prior to the test, firefighters were also oriented to the OMNI RPE scale and high and low anchors were established.

Firefighters were required to complete the skills test as fast as possible. The skills test consisted of firefighters having to advance up steps to the third floor of a concrete building while carrying a bundled, 15 m length of 4.45 cm hose line over one shoulder. Once firefighters reached the fourth floor of the building they dropped the hose line, hoisted a 15 m roll of 15 cm hose connected to a rope from the ground level to the fourth floor using a hand over hand technique, and then descended the stairs to the first floor of the building. The participant then dragged a charged, 6.4 cm hose line for 15 m. Lastly, participants dragged a rescue mannequin for approximately 15 m to complete the test. Firefighters self-reported their perceived exertion by using the OMNI Walk-Run Scale before and immediately after performing the fitness test. The firefighters were video recorded during the skills test and short video vignettes of each firefighter were produced and subsequently used in the direct kinematic video-graphic observational procedure.

Observation Procedure

Fifty-four male and female college aged students served as the trained observers. For the present investigation all exertional observations were made by these 54 individuals. The observers were all undergraduate exercise science students with moderate experience in the use of the OMNI Walk-Run Scale. A total of twenty short video vignettes (twenty certified firefighters performing a fire suppression-specific skills test as previously described) were viewed by all observers on two separate days in a randomized order. The length of the video vignettes ranged from 90 sec to 180 sec. A partial time interval sampling system was used to estimate the perceived exertion experienced by the firefighters at six separate time periods. The contextual categories were the participant and the fire ground environment. The specific set of observational keys nested within the participant category consisted of: (a) movement of the head, torso, and limbs, and (b) posture (only visual cues were used). The observational keys within the environment category included: the stairs firefighters had to ascend and descend, any obstructions encountered in transit, and the physical load that the firefighters had to carry (for example: hose and manikin). Changes in these keys informed the observed rating. The observers used the same perceived exertion definition, instructions on the use of the OMNI Scale (Figure 1), and low and high scale anchoring procedures to make their ratings. Therefore, the observation keys were evaluated using standardized scaling procedures for the observers. All observers underwent an orientation session to familiarize them to the video-graphic observational procedure, and observational keys.

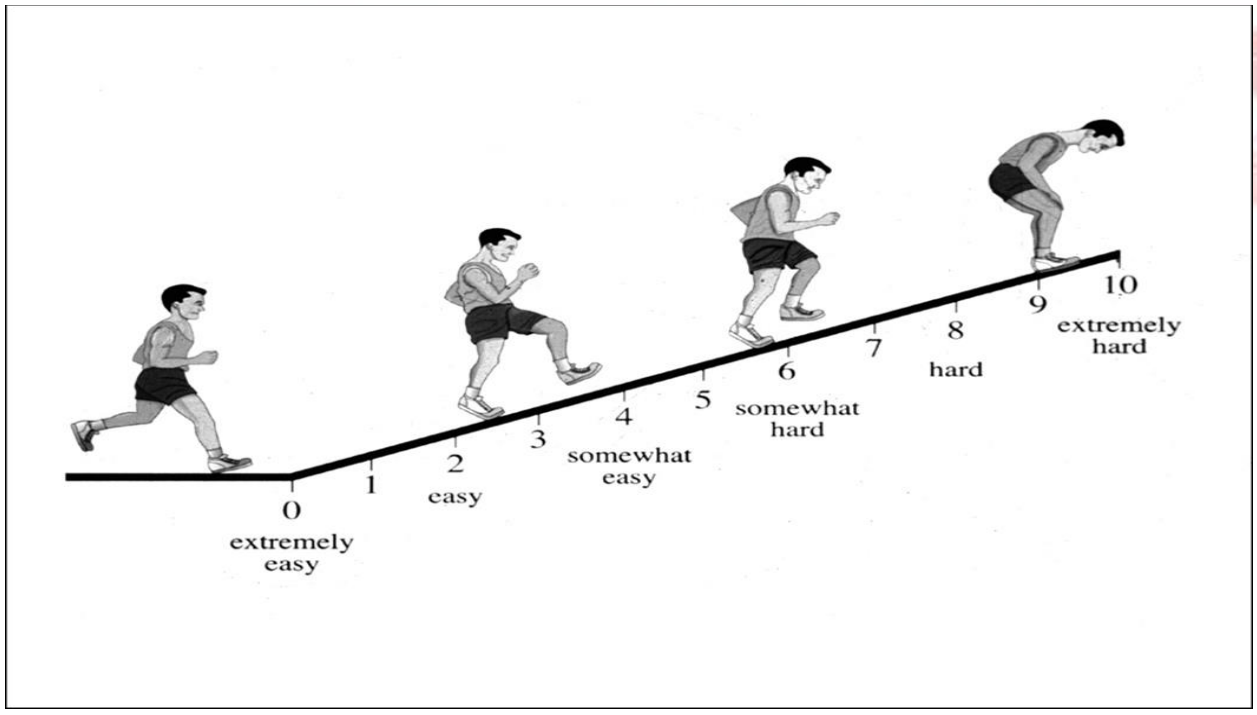

Figure 1. OMNI Scale of Perceived Exertion: Walk/Run RPE-Scale (Robertson, 2004)

During the observational trials, observers sat in a dimly lit lecture hall. An overhead projector system (Sharp XG-C330X LCD Projector, Hamburg, Germany) was used to display the stimulus material on a blank white screen. Observers were presented with twenty short video vignettes that included the firefighters performing the fitness test. The observers were cued by the investigator to estimate perceived exertion using the OMNI Walk-Run Scale at six different time points throughout each video vignette. Observers were instructed to estimate RPE for each firefighter immediately before exercise (IBE), top of stairs (TOS), bottom of stairs (BOS), immediately after hose drag (IAHD), and immediately after completing the test (IAE) (Figure 2). Observers were also asked to give rating of perceived exertion for the entire session (S). One week after the initial observational trial, observers performed the same exertional observation procedure using the same video vignettes, however the order of the presentations were randomized for the second trial.

Figure 2. Five different epochs of a firefighter fitness test: (A) immediately before exercise (IBE), (B) top of stairs (TOS), (C) bottom of stairs (BOS), (D) immediately after hose drag (IAHD), (E) immediately after exercise (IAE)

Statistical Analyses

Statistical analyses were performed using SPSS version 22.0 (SPSS Inc., Chicago, IL). Statistical significance was set a priori at $p < 0.05$. Descriptive statistics were calculated for all variables. The reliability of the video-graphic observational procedure was assessed using intraclass correlation coefficients. Validity was assessed by comparing the firefighter's self-reported estimates of RPE obtained immediately after the fitness test to the 54 observer estimates using a single sample t-test.

RESULTS

For each of the 54 raters, a deviation score was calculated, subtracting their RPE IAE rating (averaged across the two trials) from the firefighter's self-reported RPE IAE rating. The observer RPE estimates were significantly lower than the self-reported ratings (single sample t (53) = 4.77, $p < .001$, see Table 1). The difference in the mean self-reported and observer RPE was 0.54 OMNI scale units. A non-significant weak positive correlation ($p = 0.32$; $r = 0.23$; $r^2 = 0.05$) was observed between self-reported and observer ratings.

TABLE 1 Self-reported and observer ratings of perceived exertion

Variable	Observer *N*	Sample *N*	Observer Rating *M* *SD*	Self-Reported Rating *M*	*SD*	Difference *M* *SD*	*P*-Value
RPE IAE	54	20	6.86 0.84	7.40	1.64	0.54 0.84	0.001

IAE = immediate after exercise

TABLE 2 Trial means (±SD) among observer ratings of perceived exertion at six different epochs of a firefighter training session (N = 54)

Time point	Trial 1 *M*	Trial 1 *SD*	Trial 2 *M*	Trial 2 *SD*	*p*-Value*	Intraclass Correlation
IBE	1.03	0.08	0.96	0.08	0.159	0.994
TOS	4.93	0.16	4.56	0.14	0.002	0.991
BOS	5.16	0.11	5.00	0.11	0.035	0.995
IAHD	6.17	0.10	6.04	0.10	0.088	0.989
IAE	6.86	0.11	6.70	0.12	0.045	0.989
S	6.30	0.10	6.14	0.10	0.020	0.994

IBE = immediately before; TOS = top of stairs; BOS = bottom of stairs; IAHD = immediately after hose drag; IAE = immediately after; S = session rating of perceived exertion; *p values from the repeated measures ANOVA. All intraclass correlation coefficients are $p < .001$.

A 2 ×20 repeated measures ANOVA was conducted to compare the observer estimates across the two observational trials. Observer estimates were not significantly different between trials at two epochs (IBE: $p = 0.159$; IAHD: $p = 0.088$), but were significantly different at four epochs (TOS: $p = 0.002$; BOS: $p = 0.035$; IAE: $p = 0.045$; S: $p = 0.02$). Intraclass correlation coefficients indicated that RPE was reliably measured at all six points (see Table 2).

DISCUSSION

Previous investigators have obtained self-report estimates of perceived exertion in firefighters performing treadmill exercise (Gallagher et al., 2012; Hostler et al., 2014) and fire suppression activity (Smith et al., 2011; Goss et al., 2014). However, this is the first investigation to examine multiple observers' perception of firefighters' exertion while performing an occupational fitness test and to compare those estimates to self-reported ratings using video-graphic analysis. The primary aim of the present investigation was to explore the validity of a kinematic video-graphic exertional observation analysis procedure compared to self-reported RPE. We hypothesized that the self-reported ratings of perceived exertion obtained immediately before and after a firefighter fitness test would not differ from the estimate made by moderately trained observers using a video-graphic observational procedure. Secondly, we hypothesized that the observers' rating of perceived exertion would not differ between experimental sessions. Results indicated that the use of a kinematic video-graphic observational analysis technique using multiple observers to estimate RPE of firefighters performing a skills test was not

shown to be entirely accurate. However, strong consistencies were noted among ratings, indicating that observer estimates were highly reliable.

This is the first study to examine a kinematic video-graphic observational analysis technique to estimate RPE of firefighters during a fitness test. The major finding of this investigation was that this observational technique did not evidence a high degree of validity. Further evaluation indicated that observer RPE's were significantly lower than the self-reported ratings (mean difference: 0.54 ± 0.84 OMNI Scale units). Previous investigations have examined the validity of kinematic exertional observation techniques. In the study by Holzmann (1982) videotape observational coding of exertion was used based on the subject's posture, payload weight, muscular force/tension, vibration, and shock during a standardized weightlifting task. RPE estimated with the Borg category rating scale. In a subsequent investigation, Ljunggren (1986) examined concurrent validity of a kinematic observation technique to estimate RPE of subjects performing randomly presented cycle ergometer power outputs. Both the observer and subject rated perceived exertion using a Borg category-ratio scale. In these investigations observer's and subject's RPE were highly correlated (r = 0.99). The results of these previous investigations are not consistent with the findings of the current study that demonstrated that observer RPE estimates were significantly lower than the self-reported ratings (Table 1), and showed a weak correlation of r = 0.23 to self-reported ratings.

In a recent article by Goss et al. (2014) ratings of perceived exertion of 66 firefighters were obtained before, during, and immediately after performing 20 min. of fire suppression training. Using the OMNI Walk-Run Scale, RPE were self-reported by the participants and also estimated by a trained observer. Significant differences were noted between the self-reported and observer ratings immediately after fire suppression training. The difference in the mean self-reported and observer ratings of perceived exertion after fire suppression training was 0.7 OMNI scale units. This finding is in agreement with the current investigation that demonstrated a significant difference between self-reported and observer RPE immediately after exercise. However, the statistically significant difference between the observed and self-reported ratings immediately post-fitness test noted in the present investigation may be a function of the large number of observers (n = 54). The difference in the mean self-reported and observed ratings of perceived exertion immediately after exercise in the present investigation were 0.54 OMNI scale units (Table 1). The size of the difference between the observed and self-reported rating of perceived exertion obtained immediately after the fitness test was comparable to that noted during a multistage incremented treadmill test administered to children (Robertson, et al., 2006). Further, differences between observed and self-reported ratings of perceived exertion at the ventilatory breakpoint have been described to range from 0.3 to 0.6 OMNI scale units (Robertson et al., 2007).

The results from the present investigation showed strong intraclass correlations among the ratings ranging from 0.989 to 0.995 (Table 2). Therefore, even though the results indicated that direct video-graphic exertional observation might not be accurate, it is nevertheless a reliable measurement procedure. In addition, because of the comparatively small difference

between the observed and self-reported estimates of exertion (0.54 OMNI scale units) and the strong correlations that were noted among the ratings, the findings from the present investigation suggest that the video-graphic observational technique employed presently could be used to provide estimates of exertional perceptions in firefighters.

The present study compared self-reported to observer ratings of perceived exertion in firefighters performing an occupational skills test using a direct video-graphic observational procedure. Firefighting is a dangerous occupation with injury rates greater than most occupational groups (Karter & Badger, 2001). Walton et al. (2003) studied firefighters from 77 municipalities in Illinois who filed worker's compensation claims from 1992–1999. They found nearly a third of claims were for overexertion, of which 83% were related to strain or sprain. Given the high prevalence and associated costs of injuries in the fire service, understanding risk and protective factors for injury is an important topic in occupational health research. Therefore, it is potentially useful for firefighters (especially supervisors) to be trained to use a direct observational procedure to estimate ratings of perceived exertion in the fire ground setting. This technique would potentially allow them to accurately estimate the level of exertion of firefighters actively engaged in suppression activities, consequently directing that they withdraw from the fire scene when a critical level of exertion is reached. However, more research is warranted to further validate kinematic observation in firefighters to establish this critical threshold.

There are several limitations to this investigation that may have contributed to the observed outcomes. The present observers were undergraduate exercise science students with only moderate experience in using the OMNI RPE Scale especially in the context of video-graphic analysis. Future investigations should examine whether additional training and experience with the OMNI RPE Scale and video-graphic techniques will reduce the mean differences between the observer and self-reported ratings. In addition, forthcoming studies should use certified firefighters to validate kinematic observation in a field setting. Lastly, it should be noted that due to logistical constraints the present investigation was able to obtain self-reported ratings of perceived exertion at only two time points during the fitness test (IBE and IAE). Future investigations should focus on obtaining both self-reported and observed ratings of perceived exertion at numerous time points during firefighting. However, given the inherent limitations of obtaining ratings of perceived exertion during the act of fire suppression, the immediate post-training rating may prove to have the most practical utility (Goss et al. 2014).

CONCLUSION

The use of a direct kinematic video-graphic observational analysis technique to estimate RPE of firefighters during a fitness test was not shown to be statistically valid. However, strong correlations were noted between trials, indicating that observer estimates were highly reliable. The comparatively small mean difference between the observed and self-reported ratings of perceived exertion suggests that additional research on this observational technique is warranted.

ACKNOWLEDGEMENTS

This study was funded by the FEMA AFG Fire Prevention & Safety Program (EMW-2011-FP-00651). The authors declare that they have no conflict of interest derived from the outcomes of this study. The authors thank the participants for their vital contribution to this study.

REFERENCES

Bassilli, J. N., 1978. Facial motion in the perception of faces and of emotional expressions. J. Exp. Psychol. Hum. Percept. Perform. 4, 373-379.

Bingham, G. P., 1987. Kinematic form and scaling: Further investigations on the visual perception of lifted weight. J. Exp. Psychol. Hum. Percept. Perform. 13, 155-177.

Bingham, G. P., 1993. Scaling judgments of lifted weight: Lifter size and the role of the standard. Ecol. Psychol. 5, 31-64.

Colburn, D., Suyama, J., Reis, S. E., Morley, J. L., Goss, F. L., Chen, Y. F., Moore, C.D., & Hostler, D., 2011. A comparison of cooling techniques in firefighters after a live burn evolution. Prehosp. Emerg. Care. 15, 226-232.

Cutting, J. E., & Kozlowski, L. T., 1977. Recognizing friends by their walk: Gait perception without familiarity cues. Bull. Psychon. Soc. 9, 353-365.

Gallagher Jr, M., Robertson, R. J., Goss, F. L., Nagle-Stilley, E. F., Schafer, M. A., Suyama, J., & Hostler, D., 2012. Development of a perceptual hyperthermia index to evaluate heat strain during treadmill exercise. Eur. J. Appl. Physiol. 112(6), 2025-2034.

Goss, F. L., Robertson, R. J., Deldin, A., Gibbs, B. B., & Hostler, D., 2014. Observation of OMNI Scale of Perceived Exertion During Fire Suppression Training. Percept. Mot. Skills. 119(1), 183-190.

Holzmann, P., 1982. ARBAN—A new method for analysis of ergonomic effort. Appl. Ergon. 13(2), 82-86.

Hostler, D., Suyama, J., Guyette, F. X., Moore, C. G., Pryor, R. R., Khorana, P., McEntire, S. J., Comer, D., & Reis, S. E., 2014. A randomized controlled trial of aspirin and exertional heat stress activation of platelets in firefighters during exertion in thermal protective clothing. Prehosp. Emerg. Care. 18, 359-367.

Johansson, G., 1973. Visual perception of biological motion and a model for its analysis. Percept. Psychophys. 14(2), 201-211.

Karter M & Badger S., 2001. United States firefighter injuries of 2000. National Fire Protection Association Journal. 95, 49–54.

Karter, M. J., & Stein, G. P., 2011. U.S. fire department profile through 2010. National Fire Protection Association. Fire Analysis and Research Division.

Karter Jr, M. J., & Molis, J. L., 2014. US Firefighter Injuries-2013. National Fire Protection Association Journal. 105 (7), 1 - 27.

Kozlowski, L. T., & Cutting, J. E., 1977. Recognizing the sex of a walker from a dynamic point-light display. Percept. Psychophys. 21, 575-580.

Ljunggren, G., 1986. Observer ratings of perceived exertion in relation to self-ratings and heart rate. Appl. Ergon. 17, 117–125.

Noble, B. J., & Robertson, R.J., 1996. Perceived exertion. Champaign, IL: Human Kinetics.

Paridon, Stephen M., Bruce S. Alpert, Steven R. Boas, Marco E. Cabrera, Laura L.

Caldarera, Stephen R. Daniels, & Thomas R. Kimball., 2006. Clinical stress testing in the pediatric age group: A statement from the American Heart Association Council on Cardiovascular Disease in the Young, Committee on Atherosclerosis, Hypertension, and Obesity in Youth. *Circulation*, 113(15), 1905–20.

Robertson R. J., Goss F. L., & Metz K.F., 1998. Perception of physical exertion during dynamic exercise: a tribute to Professor Gunnar A. V. Borg. Percept. Mot. Skills. 86(1), 183–91.

Robertson, R. J., 2004. Perceived exertion for practitioners: Rating effort with the OMNI picture system. Champaign, IL: Human Kinetics.

Robertson, R. J., Goss, F. L., Aaron, D. J., Tessmer, K. A., Gairola, A., Ghigiarelli, J. J., & Weary, K. A., 2006. Observation of perceived exertion in children using the OMNI pictorial scale. Med Sci Sports Exerc. 38(1), 158-166.

Robertson, R.J., Goss, F.L., Aaron, D.J., Utter, A.C., & Nagle, E., 2007. OMNI Scale rating of perceived exertion at ventilatory breakpoint by direct observation of children's kinematics. Percept. Mot. Skills. 104, 975 - 984.

Runeson, S., & Frykholm, G., 1981. Visual perception of lifted weight. J. Exp. Psychol. Hum. Percept. Perform. 7, 733-740.

Runeson, S., & Frykholm, G., 1983 Kinematic specification of dynamics as an informational basis for person-and-action perception: Expectation, gender recognition, and deceptive intention. J. Exp. Psychol. Gen. 112, 585-615.

Smith, D. L., Petruzzello, S. J., Goldstein, E., Ahmad, U., Tangella, K., Freund, G. G., & Horn, G. P., 2011. Effect of live-fire training drills on firefighters' platelet number and function. Prehosp. Emerg. Care.15 (2), 233-239.

U.S. Department of Labor, Bureau of Labor Statistics, 2006. Fatal occupational injuries, employment, and rates of fatal occupational injuries by selected worker characteristics, occupations, and industries, 2006.

Walton, S. M., Conrad, K. M., Furner, S. E., & Samo, D. G., 2003. Cause, type, and workers' compensation costs of injury to firefighters. Am. J. Ind. Med. 43, 454–458.