CONTINUING EDUCATION

The Benefits and Risks of CrossFit

A Systematic Review

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Abstract: With the increase in popularity of the CrossFit exercise program, occupational health nurses may be asked questions about the appropriateness of CrossFit training for workers. This systematic literature review was conducted to analyze the current research on CrossFit, and assess the benefits and risks of this exercise strategy. Thirteen studies (N = 2,326 participants) examined the use of CrossFit training among adults; CrossFit is comparable to other exercise programs with similar injury rates and health outcomes. Occupational health nurses should assess previous injuries prior to recommending this form of exercise. Ideal candidates for CrossFit are adults who seek high-intensity exercise with a wide variety of exercise components.

Keywords: health promotion, best practices, disease prevention, occupational injuries, safety, high-intensity interval training

Today, participation in high-intensity group exercise programs is gaining attention (Teetor, 2014). CrossFit, a form of high-intensity interval training (Milanović, Sporiš, & Weston, 2015), is one such exercise program that has grown rapidly since its inception in 2000. Although there is no official count of how many people participate in CrossFit, it has been estimated that the program is used at more than 2,000 facilities worldwide (Longe, 2012). CrossFit was originally designed to train individuals (e.g., police officers, military special forces) whose work requires physical fitness and muscle strength so these workers could transform from low to high levels of effort in seconds. Intended to improve movement efficiency, the program incorporates various functional movements to promote muscle strength and cardiorespiratory fitness (Weisenthal, Beck, Maloney, DeHaven, & Giordano, 2014).

CrossFit's specific modes of exercise include power/Olympic lifting (i.e., squats, cleans, deadlifts, bench press, and presses), gymnastics (i.e., pull-ups, lunges, knees to elbows, handstand push-ups, push-ups, and sit-ups), and aerobic exercise/metabolic conditioning (i.e., swimming, running, and rowing; Longe, 2012; Weisenthal et al., 2014). These exercise movements are often performed for specific lengths of time, with little to no rest at high intensity (Weisenthal et al., 2014). CrossFit workouts are scalable, so the exercises can be performed safely and effectively, given an individual's current level of fitness (Longe, 2012).

With the popularity of such programs, however, come concerns about possible injuries; occupational health nurses may be asked to answer questions about the appropriateness of CrossFit for workers. The purpose of this literature review was to assess benefits and risks associated with participation in CrossFit.

Method

A systematic review of the literature used the PRISMA protocol (Moher, Liberati, Tetzlaff, & Altman, 2009), searching PubMed, SPORTDiscus, and Combined Arms Research Library (CARL) databases (Figure 1). The search terms "CrossFit" and "high-intensity interval training" were chosen to yield the largest number of published articles. Inclusion criteria included full-text research articles exploring CrossFit with adult participants published in English. Studies of children or adolescents were excluded; case studies, review articles, and articles that did not present research or were opinion pieces were also excluded.

Results

A total of 13 studies examined the use of CrossFit for adults (Table 1). The total sample for all 13 studies was N = 2,326. Sample sizes for individual studies ranged from 10 to 1,393. The studies were conducted internationally, including the United States (n = 10), Canada (n = 1), Poland (n = 1), and an international online forum (n = 1). The studies fell into two groups: those that assessed the benefits of CrossFit and those that reported CrossFit injury rates. Although most of the

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Applying Research to Practice

CrossFit is a form of high-intensity interval training. It is comparable to other high-intensity exercise regimens in terms of both injury rates and health outcomes. CrossFit, just as any other high-intensity training, increases VO_2 max, strength, musculature, and endurance, and decreases lean body mass. With proper training and incremental increases in intensity, CrossFit can be an effective form of exercise for healthy adults looking for a diverse workout routine.

studies included both men and women, one included only women (Heinrich, Patel, O'Neal, & Heinrich, 2014), and two included only men (Bellar, Hatchett, Judge, Breaux, & Marcus, 2015; Kliszczewicz et al., 2015). One study was conducted on a university campus with college students (Barfield, Channell, Pugh, Tuck, & Pendel, 2012), and three examined CrossFit as part of military training (Grier, Canham-Chervak, McNulty, & Jones, 2013; Knapik, 2015; Paine, Uptgraft, & Wylie, 2010). None of the studies were conducted in an occupational setting. All of the studies included healthy adults, but participants varied in levels of CrossFit experience; in one study, novices were compared with experienced CrossFit athletes (Bellar et al., 2015).

Injury Rates

Three studies reported injuries due to CrossFit, and one examined postexercise dysfunction. Injury rates among CrossFit participants were comparable to rates for other recreational or professional athletes (Chachula, Cameron, & Svoboda, 2016; Grier et al., 2013; Hak, Hodzovic, & Hickey, 2013; Weisenthal et al., 2014). Hak et al. (2013) reported CrossFit injury rates and patterns of injuries among 386 individuals; the overall injury rate was 19.4%, with males injured more frequently than females. The most common areas for injury were the shoulders, lower back, and knees. However, injury rates decreased with trainer involvement. Chachula et al. (2016) reported that participants with prior injuries were 3.75 times more susceptible to reinjury.

Grier et al. (2013) reviewed medical records of U.S. Army brigade combat team members spanning 6 months before and 6 months after the implementation of a new fitness program that incorporated CrossFit training and Ranger Athlete Warrior Program, both of which are considered extreme conditioning programs (ECPs), along with Advanced Tactical Athlete Conditioning (ATAC). Injury rates for participants in the ATAC/ECPs were consistent with rates for nonparticipants. Grier et al. found that injuries could be minimized with less long-distance running and more resistance training.

Hak et al. (2013) examined CrossFit-related injuries reported by 132 participants who responded to an online questionnaire; the most common injuries were shoulder injuries, spinal injuries (especially the lower back), and arm or elbow injuries. No incidence of rhabdomyolysis was reported. Injuries to the shoulder accounted for 25.8% of total injuries. Hak et al. suggested that CrossFit is safe for all athletes when activities are performed correctly in a safe environment with trainers; however, those athletes who report previous injuries should take precautions to avoid reinjury as in any sport.

Drum, Bellovary, Jensen, Moore, and Donath (2016) compared CrossFit training with American College of Sports Medicine (ACSM) training guidelines. In this study, the authors collected data on excessive muscle soreness postexercise, delayed onset muscle soreness, and shortness of breath via questionnaire; they also collected participant-reported ratings of perceived exertion (RPEs). CrossFit participants' RPEs were higher, 7.3 ± 1.7, than those for ACSM, 5.5 ± 1.4 ($p \leq .001$). Postexercise symptoms were also higher for CrossFit than for ACSM, respectively: excessive fatigue, 42 versus 8 ($p < .001$); muscle soreness, 96 versus 48 ($p = .04$); muscle swelling, 19 versus 4 ($p = .048$); shortness of breath, 13 versus 1 ($p = .02$); muscle painful to touch, 31 versus 4 ($p = .001$); and limited muscle movement during workouts, 37 versus 9 ($p = .007$). Thus, those individuals who train with CrossFit can expect greater postexercise pain than they might experience with other exercise routines. Drum et al. suggested that athletes should scale their training with planned rest cycles to avoid overuse and prevent injury.

Novices Versus Experts

Two of the studies compared outcomes for novice versus expert CrossFit participants. Butcher, Judd, Benko, Horvey, and Pshyk (2015) compared two different CrossFit-based multimodal workouts: multimodal circuit training (MMCIR) and multimodal high-intensity interval training (MMHIIT): In total, 57 participants completed the two workouts on different days. Butcher et al. examined heart rate (HR) and RPEs during both workouts, as well as the differences between novices and experts. Overall, mean HR was lower in the MMHIIT group (76% ± 7% predmax) than in the MMCIR group (88% ± 6% predmax); both groups had similar RPEs (17 ± 2 vs. 18 ± 1 on a scale of 20, respectively). Experienced participants in both groups had an overall higher mean HR but no differences in RPE. According to Butcher et al., the intensity of both types of CrossFit workouts was at the higher end of guidelines for health and exercise, and may increase cardiovascular fitness.

Bellar et al. (2015) measured VO_2 max and anaerobic power in 32 male participants who were either naïve to CrossFit or highly experienced, and found that their history of CrossFit participation was associated with higher performance in CrossFit workouts ($F = 35.72$, $p \leq .001$). Participants with greater experience had better aerobic capacity and anaerobic power.

Comparison Studies

In three of the studies, CrossFit was compared with other high-intensity functional training (HIFT) programs. Heinrich

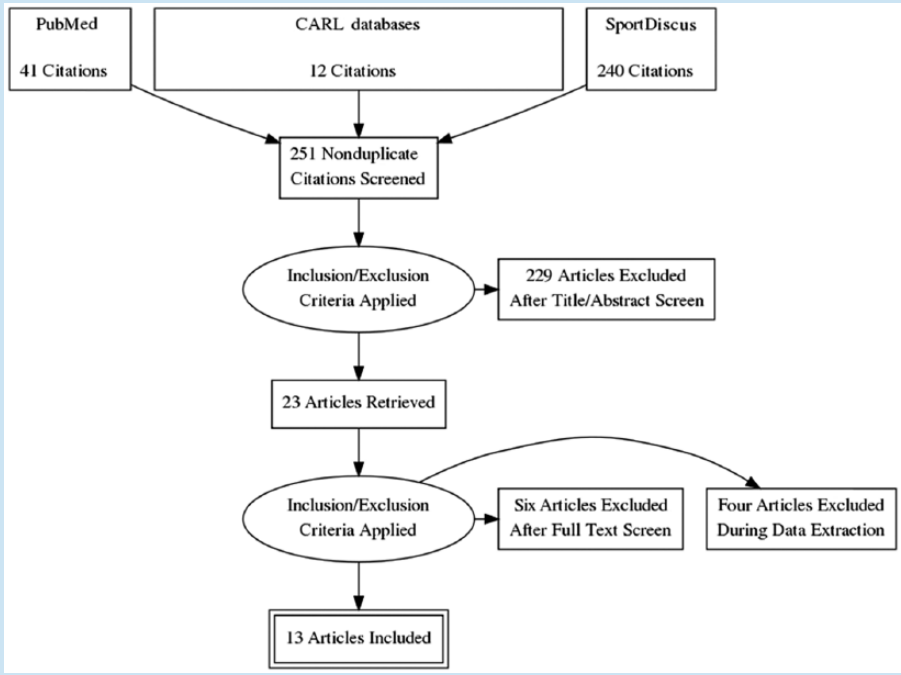

Figure 1. Study selection.
Note. **CARL = Combined Arms Research Library.**

et al. (2014) studied 23 participants, examined exercise enjoyment, and compared standard aerobic and resistance training (ART) with group-based HIFT using CrossFit. The ART group reported lower exercise enjoyment than the CrossFit HIFT group. High intensity functional training participants reported higher exercise enjoyment (p = .049) than participants in the aerobic exercise control group.

Kliszczewicz et al. (2015), who studied 10 participants, compared a high-intensity treadmill workout with a CrossFit workout, focusing on acute oxidative stress. Blood plasma was tested preexercise, immediately following workout, 1 hour after exercise, and finally 2 hours after exercise for oxidative damage from high-intensity exercise and antioxidant capacity. The CrossFit workout demonstrated oxidative stress comparable to the oxidative stress following the high-intensity workout. Oxidative stress is particularly sensitive to the level of exercise intensity.

In a semester-long study of 87 college students, Barfield et al. (2012) compared three exercise groups: an instructor-led traditional class, an independent class (the instructor provided a training program, but students followed it on their own), and CrossFit training with a coach. The authors measured body composition and muscular strength, endurance, and power at the beginning and end of the semester. The instructor-led traditional group had significant improvement in comparison with the other two groups for both muscle power and strength (p = .008). However, the CrossFit resistance training participants showed fitness gains at an average of 17%. This study did not report statistical power; it is possible that it lacked sufficient power because only 20 matched participants were included per group.

Physiological Benefits of CrossFit

Smith, Sommer, Starkoff, and Devor (2013) measured changes in VO_2 max, body composition, and aerobic capacity in a 10-week study of 43 men and women participating in CrossFit-based high-intensity power training (HIPT). These participants, who were also following a Paleolithic diet, presented all levels of fitness, body composition (measured with the BOD POD, an air displacement plethysmography device), and VO_2 max (measured by a max treadmill test using Bruce protocol). The maximum volume of oxygen consumption (VO_2 max) serves as a proxy for fitness. Over the 10 weeks, body fat percentages dropped 3.7% (p = .00008) and VO_2 max improved from 11.8% to 13.6% (p = .001). Smith et al. concluded that CrossFit training and HIPT can improve aerobic capacity and body composition among individuals with varying levels of fitness; the changes in body composition might have been due to diet or a combination of diet and exercise.

In a study of younger participants using CrossFit, Murawska-Cialowicz, Wojna, and Zuwala-Jagiello (2015) assessed changes in brain-derived neurotrophic factor (BDNF), a protein that enhances the production of neurons, irisin, physical performance, body mass/composition, and muscle circumference during a 3-month training program. The exercise-induced hormone, irisin, increases the expenditure of energy; in

Table 1. Studies Using CrossFit

Author(s)	Design	Population/setting	Outcomes/dependent variables	Results—physical fitness outcomes
Chachula, Cameron, and Svoboda (2016)	Cross-sectional incidence and prevalence	*n* = 54 Female *n* = 14 Male *n* = 40 Age = 17-50 Army post	Injuries rates and prevalence	Found correlation with previous joint injuries and CF-related injuries Injury prevalence was 44% (24 of 54) Those without prior injuries were 22% (four of 18) Decrease in injuries if a trainer is present
Barfield, Channell, Pugh, Tuck, and Pendel (2012)	Three-arm nonrandomized convenience sample	*n* = 60 university students	BMI Muscular strength Muscular endurance Muscular power	Changes in two fitness variables (muscular power and muscular strength) differed significantly ($p < .008$) by class format Muscular power improvements were significantly greater among traditional formats The CF format showed a significantly greater mean gain than independent formats
Butcher, Judd, Benko, Horvey, and Pshyk (2015)	Two-arm comparison Observational/cross-sectional study	*n* = 57 All from a registered CF affiliate (Saskatchewan, Canada)	HR RPEs	Both MMHIIT and MMCIR resulted in high HRs (averaging 76% and 88% of HR, respectively) Mean HR for MMHIIT (76% ± 7% predmax) was significantly lower than during MMCIR (88% ± 6% predmax) despite similar RPE scores (17 ± 2 vs. 18 ± 1 on a scale of 20, respectively) Experienced participants (*n* = 22) had a higher HR than the novice group (*n* = 35) during MMCIR and MMHIIT No differences in RPE Experienced athletes demonstrated a greater ability to sustain higher HRs
Drum, Bellovary, Jensen, Moore, and Donath (2016)	Two-arm nonrandomized convenient sample	*n* = 157 adults	Postexercise physical dysfunction (excessive muscle soreness and shortness of breath)	CF leads to “very hard” perceived exertion
Murawska-Cialowicz, Wojna, and Zuwala-Jagiello (2015)	Cross-sectional correlation	*n* = 12 adults in Poland	BDNF Irisin levels Physical performance Body mass VO_2 max	BDNF was lower in men after Wingate and progressive tests than at rest There were no differences in irisin levels between the baseline and 3 months after the training after Wingate and progressive tests
Bellar, Hatchett, Judge, Breaux, and Marcus (2015)	Cross-sectional descriptive, linear regression	*n* = 32 healthy adult males	Aerobic capacity Anaerobic power VO_2 max CF experience	Age, CF experience (naïve or CF athlete), VO_2 max, and anaerobic power significantly fit the model to predict ($p < .05$) performance in the first workout. Performance in the second workout was predicted by CF experience only

(continued)

Table 1. (continued)

Author(s)	Design	Population/setting	Outcomes/dependent variables	Results—physical fitness outcomes
Kliszczewicz et al. (2015)	Two-arm randomized crossover; the same participants were in both groups	*n* = 10 males with 3+ months of CF experience	Oxidative damage Antioxidative capacity	No differences were observed in any biomarker of oxidative stress between exercise intensity and the time course of exercise recovery influencing oxidative responses
Heinrich, Patel, O'Neal, and Heinrich (2014)	Stratified/randomized two-group pretest/posttest intervention	*n* = 32 8 weeks White, college-educated females	Reasons for exercise, exercise enjoyment, and exercise intentions.	HIFT spent less time exercising per week yet maintained exercise enjoyment and more likely to continue HIIT should be included in public health interventions
Weisenthal, Beck, Maloney, DeHaven, and Giordano (2014)	Epidemiology Cross-sectional descriptive	*n* = 386 CF gyms in New York and Pennsylvania	Injuries	Overall injury rate was 19.4% (75 of 386) Men were more likely to sustain an injury (53 of 231) Injuries decrease with the use of trainers ($p = .028$) Injury rates were significantly different ($p = .001$), with shoulder (21 of 84), low back (12 of 84), and knee (11 of 84) being the most commonly injured areas
Hak, Hodzovic, and Hickey (2013)	Observational descriptive	*n* = 132 International online forums	Demographics, training programs, injury profiles, and supplement use	About 97 (73.5%) sustained an injury during CF In total 186 injuries were reported, with nine (7%) requiring surgical intervention Injury rate was 3.1 per 1,000 hours trained No incidence of rhabdomyolysis was reported
Grier, Canham-Chervak, McNulty, and Jones (2013)	To assess ECPs	*n* = 1,393 soldiers in a light infantry brigade combat team	Personal characteristics, tobacco, PFT, and self-reported injuries	Injury incidence increased 12% for overall injuries and 16% for overuse injuries after the implementation of ECP Injury increase for soldiers *not* using ECP was 14%, and overuse increased 10%
Smith, Sommer, Starkoff, and Devor (2013)	Cross-sectional descriptive and correlation	*n* = 43 adults of varying levels of fitness	Body fat percentage VO_2 max	Results showed significant ($p < .05$) improvements of VO_2 max in men (43.10 ± 1.40 to 48.96 ± 1.42 mL/kg/min) and women (35.98 ± 1.60 to 40.22 ± 1.62 mL/kg/min) Decreased body fat percentage in men (22.2 ± 1.3 to 18.0 ± 1.3) and women (26.6 ± 2.0 to 23.2 ± 2.0) Significant correlations between absolute oxygen consumption and oxygen consumption relative to body weight was found in both men ($r = .83$, $p < .001$) and women ($r = .94$, $p < .001$)
Paine, Uptgraft, and Wylie (2010)	Pre-/posttest one-group intervention	*n* = 14 military officers at command and general college staff 8 weeks of physical training using CF	Physical fitness	After 6 weeks of training, the athletes increased their level of physical fitness by 20% Increases were relatively equal across the four assessments

Note. CF = CrossFit; BMI = body mass index; HR = heart rate; RPE = rating of perceived exertion; MMHIIT = multimodal high-intensity interval training; MMCIR = multimodal circuit; BDNF = brain-derived neurotrophic factor; HIFT = high-intensity functional training; HIIT = high-intensity interval training; PFT = Physical Fitness Training; ECP = extreme conditioning program.

some animal models, irisin decreases obesity and insulin resistance (Sanchis-Gomar, Lippi, Mayero, Perez-Quilis, & García-Giménez, 2012), increases aerobic capacity, increases VO_2 max (p = .02), reduces adipose tissue percentage (p = .02) in women, and increases lean body mass (p = .004; Murawska-Cialowicz et al., 2015) in all participants. Brain-derived neurotrophic factor levels showed marked increases in all participants; irisin levels showed no change.

Discussion

Overall, the research on the effectiveness of CrossFit in improving physical fitness among adults is not extensive. The literature search located only 13 studies that examined CrossFit in various ways, including consideration of its safety and benefits.

Every form of physical activity holds a potential risk for injury (Oh, 2013). Rates for CrossFit training injuries are consistent with those rates for injuries that occupational health nurses routinely encounter for workers who engage in other fitness routines. Approximately 74% of all runners, for example, experience a moderate or severe injury each year (Daoud et al., 2012), which is much higher than the injury rate of 19.4% among CrossFit participants (Weisenthal et al., 2014). A history of previous injury predisposes those who train with CrossFit to reinjury (Chachula et al., 2016), which is also consistent with the findings of other sport-related injury studies (e.g., Hespanhol, Pena Costa, & Lopes, 2013). Chachula et al.'s (2016) study examined 12 elite soccer players and injury rates; players who had previous injuries had almost three times the risk of reinjury. Occupational health nurses should consider individuals' histories of injury and injury patterns (Oh, 2013) before CrossFit is recommended.

As the present literature review suggests, individuals experienced in CrossFit perform better and have higher gains in aerobic capacity and anaerobic power than do CrossFit beginners (Bellar et al., 2015; Butcher et al., 2015). When a CrossFit athlete is familiar with the program's movements, exercises, and expectations, CrossFit's effectiveness increases as well. To benefit most from CrossFit, it is best to find a CrossFit gym with an "On-Ramp" program, which provides instruction on fundamental CrossFit movements as well as CrossFit-certified coaches (Oh, 2013). Novices may experience less physical change during their initial sessions, so they should be encouraged to continue to gain the exercise regimen's full benefits.

Barfield et al.'s (2012) comparison study found that traditional exercise provided greater muscular fitness gains than did CrossFit workouts. It may be that the mode of exercise did not matter as much as the exercise intensity, which is difficult to measure. Kliszczewicz et al. (2015) have shown that the intensity of routines and movements provides the most benefit to participants. In addition, the sample size in Barfield et al.'s study may have been inadequate, and Barfield et al. did not measure exercise enjoyment. Heinrich et al. (2014), on the contrary, showed that participants in a CrossFit HIFT group could maintain exercise enjoyment and were more likely to continue in the program. Occupational health nurses who care for workers should select exercise routines that stress the importance of exercise intensity and enjoyment to optimize outcomes.

Nursing Implications

With more than 13,000 licensed CrossFit affiliates worldwide (CrossFit, 2016) and throughout the United States, occupational health nurses have general knowledge of CrossFit exercise programs because they may encounter clients engaged in or planning to engage in such activities. With an understanding of CrossFit's benefits and risks as well as exercise safeguards, occupational health nurses can safely consult with clients who are interested in CrossFit training. Nurses should assess previous injuries and possible limitations prior to recommending CrossFit; nurses can recommend their clients find gyms with On-Ramp programs or classes of basic CrossFit movements used in the workouts (Oh, 2013). When treating injuries from CrossFit, nurses should be aware of CrossFit-certified trainers' ability to individualize and scale workouts for those injured or recovering. The effective scaling of workouts should address the unique needs of each athlete adequately (CrossFit, 2016).

Conclusion

In summary, CrossFit is comparable to other high-intensity exercise regimens in terms of both injury rates and health outcomes. CrossFit, just as any other high-intensity training, increases VO_2 max, strength, musculature, and endurance, and decreases lean body mass. With proper training and incremental increases in intensity, CrossFit can be an effective form of exercise for healthy adults looking for a diverse workout routine.

Conflict of Interest

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References

Barfield, J. P., Channell, B., Pugh, C., Tuck, M., & Pendel, D. (2012). Format of basic instruction program resistance training classes: Effect on fitness change in college students. *The Physical Educator*, *69*, 325-341.

Bellar, D., Hatchett, A., Judge, L. W., Breaux, M. E., & Marcus, L. (2015). The relationship of aerobic capacity, anaerobic peak power and experience to performance in HIT exercise. *Biology of Sport*, *32*, 315-320. doi:10.5604/20831862.1174771

Butcher, S. J., Judd, T. B., Benko, C. R., Horvey, K. J., & Pshyk, A. D. (2015). Relative intensity of two types of CrossFit exercise: Acute circuit and high-intensity interval exercise. *Journal of Fitness Research*, *4*(2), 3-16.

Chachula, L. A., Cameron, K. L., & Svoboda, S. J. (2016). Association of prior injury with the report of new injuries sustained during CrossFit training. *Athletic Training & Sports Health Care*, *8*, 28-34. doi:10.3928/19425864-20151119-02

CrossFit. (2016). *How to start CrossFit?* Retrieved from https://www.crossfit.com/how-to-start

Daoud, A. I., Geissler, G. J., Wang, F., Saretsky, J, Daoud, Y. A., & Lieberman, D. E. (2012). Foot strike and injury rates in endurance runners: A retrospective study. *Medicine & Science in Sports & Exercise*, *44*, 1325-1334. doi:10.1249/mss.0b013e3182465115

Drum, S. N., Bellovary, B., Jensen, R., Moore, M., & Donath, L. (2016). Perceived demands and post-exercise physical dysfunction in CrossFit® compared to an ACSM based training session. *The Journal of Sports Medicine and Physical Fitness*. Advance online publication. Retrieved from http://www.minervamedica.it/en/journals/sports-med-physical-fitness/article.php?cod=R40Y9999N00A16021203

Grier, T., Canham-Chervak, M., McNulty, V., & Jones, B. H. (2013, October-December). Extreme conditioning programs and injury risk in a US Army brigade combat team. *The United States Army Medical Department Journal*, pp. 36-47.

Hak, P. T., Hodzovic, E., & Hickey, B. (2013). The nature and prevalence of injury during CrossFit training. *Journal of Strength and Conditioning Research*. Advance online publication. doi:10.1519/JSC.0000000000000318

Heinrich, K. M., Patel, P. M., O'Neal, J. L., & Heinrich, B. S. (2014). High-intensity compared to moderate-intensity training for exercise initiation, enjoyment, adherence, and intentions: An intervention study. *BMC Public Health*, *14*(1), Article 789. doi:10.1186/1471-2458-14-789

Hespanhol, L. C., Jr., Pena Costa, L. O., & Lopes, A. D. (2013). Previous injuries and some training characteristics predict running-related injuries in recreational runners: A prospective cohort study. *Journal of Physiotherapy*, *59*, 263-269. doi:10.1016/s1836-9553(13)70203-0

Kliszczewicz, B., Quindry, J. C., Blessing, D. L., Oliver, G. D., Esco, M. R., & Taylor, J. K. (2015). Acute exercise and oxidative stress: CrossFit™ vs. treadmill bout. *Journal of Human Kinetics*, *47*(1), 81-90. doi:10.1515/hukin-2015-0064

Knapik, J. J. (2015). Extreme conditioning programs: Potential benefits and potential risks. *Journal of Special Operations Medicine*, *15*, 108-113.

Longe, J. L. (2012). CrossFit. In J. L. Longe (Ed.), *The Gale encyclopedia of fitness* (Vol. 1, pp. 206-209). Detroit, MI: Gale, Cengage Learning.

Milanović, Z., Sporiš, G., & Weston, M. (2015). Effectiveness of high-intensity interval training (HIT) and continuous endurance training for VO_2 max improvements: A systematic review and meta-analysis of controlled trials. *Sports Medicine*, *45*, 1469-1481. doi:10.1007/s40279-015-0365-0

Moher, D., Liberati, A., Tetzlaff, J., & Altman, D. G. (2009). Preferred reporting items for systematic reviews and meta-analyses: The PRISMA statement. *Annals of Internal Medicine*, *151*, 264-269. doi:10.7326/0003-4819-151-4-200908180-00135

Murawska-Cialowicz, E., Wojna, J., & Zuwala-Jagiello, J. (2015). CrossFit training changes brain-derived neurotrophic factor and irisin levels at rest, after Wingate and progressive tests, and improves aerobic capacity and body composition of young physically active men and women. *Journal of Physiology and Pharmacology*, *66*, 811-821.

Oh, R. C. (2013). Coming out of the CrossFit closet. *The Uniformed Family Physician*, *7*(1), 31-33.

Paine, J., Uptgraft, J., & Wylie, R. (2010). *CGSC CrossFit study* (Special report). Fort Leavenworth, KS: Command and General Staff College. Retrieved from http://purl.access.gpo.vob/GPO/LPS21074

Sanchis-Gomar, F., Lippi, G., Mayero, S., Perez-Quilis, C., & García-Giménez, J. L. (2012). Irisin: A new potential hormonal target for the treatment of obesity and type 2 diabetes. *Journal of Diabetes*, *4*, 196. doi:10.1111/j.1753-0407.2012.00194.x

Smith, M. M., Sommer, A. J., Starkoff, B. E., & Devor, S. T. (2013). CrossFit-based high-intensity power training improves maximal aerobic fitness and body composition. *Journal of Strength and Conditioning Research*, *27*, 3159-3172. doi:10.1519/jsc.0b013e318289e59f

Teetor, P. (2014, August 4). The story of how CrossFit went from zero to 10,000 locations. *LA Weekly*. Retrieved from http://www.laweekly.com/arts/the-story-of-how-crossfit-went-from-zero-to-10-000-locations-5005604

Weisenthal, B. M., Beck, C. A., Maloney, M. D., DeHaven, K. E., & Giordano, B. D. (2014). Injury rate and patterns among CrossFit athletes. *The Orthopaedic Journal of Sports Medicine*, *2*(4). doi:10.1177/2325967114531177

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