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RESEARCH ARTICLE

Evaluation of FMS Scores of Competitive CrossFit Athletes by Gender

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Abstract
Functional Movement Screening System (FMS) is a testing and assessment protocol used to evaluate the body movement and movement capacity of athletes or physically active individuals. Analysis of FMS scores by gender can provide important information to personalize training programs, identify weak points, and improve the movement quality of athletes. Therefore, the aim of this study was to evaluate the FMS scores of competitive CrossFit athletes according to gender. A total of 22 athletes, 14 males with a mean age of 26.79±5.16 years and 8 females with a mean age of 32.38±3.74 years participated in the study. Participants were administered the FMS™ test consisting of seven tasks (per the FMS™ manual). In the analysis of the data, after the normality distribution was made, the Man-Whitney U test was performed for the data that did not show the normal distribution in an independent two-group comparison. A statistically significant difference was found in the right(p=0.04) and left (p=0.04) shoulder mobility score, shoulder mobility final score (p=0.01), and active straight leg raise score-right (p=0.02) measurements of the athletes according to gender. As a result, females were found to have higher 'shoulder mobility' and 'active straight leg raising' scores than males on a movement basis. In addition, the total FMS scores were found to be above average for both genders.

Keywords
Crossfit, FMS, Gender, Injury Prevention

INTRODUCTION

CrossFit is one of the fastest-growing physical activities of high-intensity functional training, which emerged in the late 1990s and early 2000s. This strength and conditioning program is employed to enhance various physical abilities, including flexibility, cardiovascular and respiratory endurance, strength, speed, power, balance, agility and coordination. CrossFit training is characterized by its emphasis on high-intensity, functional movements (Claudino et al. 2018; Clifford, 2016; Feito et al. 2018). Some of the reasons behind the popularization of CrossFit training are that it includes three different sports branches (gymnastics, condition, and Olympic weightlifting), and its constantly changing philosophy that encourages functional movements (Summitt et al. 2016). Due to the fact that it has more than one branch, individuals need to push and develop themselves in this, and they need to have a certain level of mobilization and stabilization in order to do this. This indicates a substantial risk of injury for athletes. In addition, the literature has shown that CrossFit athletes are at the highest risk for upper extremity injuries (Rodriguez et al. 2021; Stracciolini et al. 2020; Toledo et al. 2021; Weisenthal et al. 2014). According to a 2014 study by Weisenthal et al., the injury rate among CrossFit athletes in the United States was found to be 19.4%, based on survey responses from 386 participants (Weisenthal et al. 2014). In another study, 97 (73.5%) of 132

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participants reported that they experienced musculoskeletal injuries during CrossFit training (Summitt et al. 2016). Sarıçam et al. (2022) also reported that the areas with the highest number of injuries were the shoulder, back, waist, arm, and elbow. It has been reported that male athletes are more likely to experience injury than female athletes. However, the participants in these studies are not competitive athletes (Shim et al. 2023; Weisenthal et al. 2014).

To achieve peak performance and minimize the risk of injury, it's crucial to detect any irregularities or weaknesses in intramuscular and intermuscular coordination. Data from multiple studies have shown that FMS levels can predict injury and these data identify a potential level of proficiency barrier (Bardenett et al. 2015; Chorba et al. 2010; Kiesel et al. 2007; Letafatkar et al. 2014). The objective of FMS is to pinpoint areas of weakness, reduced stability, or limited mobility within the body, within a dynamic and functional context (Cook et al. 2014; Kiesel et al. 2007). FMS is an assessment tool that defines the quality of movement and requires both balance and stability. It is popular in many fitness and rehabilitation areas (Cook et al. 2006; Gulgin and Hoogenboom, 2014). The FMS test consists of seven core exercises, including the hurdle step, the deep squat, the inline lunge, the active straight leg raise, shoulder mobility, rotary stability, and trunk stability push-ups. It is evaluated on a scale of 0 to 3 according to specific grading criteria (Cook et al. 2006). The FMS test is designed to detect mobility issues and subsequently suggest exercises tailored to address identified dysfunctions and limitations. So it enhances both strength and flexibility (Frost et al. 2012; Needham and Chockalingam, 2015). Several studies have indicated that a minimum total FMS score of ≥14 is recommended for the prevention of disabilities (Bardenett, 2015; Chorba et al. 2010; Kiesel et al. 2007; Letafatkar et al. 2014). However, studies on the injury levels of competing athletes and gender-related injuries are limited. Therefore, the aim of this study is to determine the types of gender-related injuries in high-intensity CrossFit exercises as a preventive measure for future injuries.

MATERIALS AND METHODS

Participants

This research was conducted in Istanbul on 14 male and 8 female volunteer athletes who have been doing CrossFit at a professional level for at least 2 years and participated in at least 1 national or international competition. The test was done in the gym where they trained the athletes and in a quiet. Before the research, each participant was informed about the structure of the research and its possible risks. Athletes were told that they could leave the test at any time. In addition, before the test, the athletes were told not to do any mobility and stretching exercises. Athletes who had undergone any injury, surgery, or medical procedure in the past three months were excluded from the study. In addition, written and signed consents were obtained from all participants. The research has been approved by the Scientific Research Ethics Committee that the research structure is in compliance with the Helsinki Declaration on "Ethical Principles in Medical Research on Humans" (2023/15- 23/494).

Data Collection

The FMS assessment was conducted by researchers holding FMS Level 1 certifications, and an overall FMS score was documented for each individual athlete. The researchers conduct FMS assessments for each athlete, utilizing the FMS test kit and accompanying manual provided by Functional Movement Systems to uphold the test's integrity. Athletes underwent the complete FMS assessment, sequentially performing all seven movements while being evaluated by the researcher. The FMS assessment encompasses the following movements: hurdle step, deep squat, inline lunge, active straight leg raise, shoulder mobility, rotary stability, and trunk stability push-ups.

FMS Score

The researchers applied the FMS scoring protocol to assess each test, assigning ratings on a scale from 1 to 3 (1 = unable to perform the movement pattern as described, 2 = movement completed with compensation(s), 3 = movement completed perfectly as verbally described without any compensations). A composite score for each athlete was calculated and recorded, as well as individual scores for each of the seven test positions.

FMS Test Measurements

Deep squat test

The athlete, held the bar with the legs slightly wider than shoulder-width apart and with both hands with the elbows at 90°. With his arms up and over his head, he squatted slowly and tried to keep both feet on the ground. Keeping the natural curvature of the head and trunk, holding the bar over the head 3 times in a row, and the test score was recorded.

Hurdle step test

The feet of the athletes were close to each other and their fingers were under the hurdle. The hurdle was adjusted to the same height as the athlete's tibial tubercle. The athlete slowly lifted one leg over the hurdle and the support leg remained upright. The athlete touched the ground with the heel, and slowly returned to the starting position. Completed 3 times in a row and recorded the test score. Then athletes did the other leg in the same way and the test was completed.

Inline lunge

The length of the individual from the ground to the tuberosities tibia is measured. The subject places one foot on the wooden block, opens the other foot to the length of the tibia determined, and positions it so that it is in line with the back foot. The hand on the opposite side of the front foot holds the measuring stick in the cervical region, while the other hand grasps it in the lumbar region. While maintaining an upright posture, the person lowers the back knee enough to touch the surface behind the heel of the front foot and returns to the starting position.

Shoulder mobilitiy test

Hand length is determined by measuring the distance from the distal wrist bend to the tip of the third digit. The individual is instructed to make a fist with both hands and to assume a position of maximum adduction, extension, and internal rotation with one shoulder and maximum abduction, flexion, and external rotation with the other. During the test, the hands should remain in fists and the fists should be placed comfortably on the back. In this position, the distance between the nearest bony prominences in the fists is measured.

The active straight leg raise test

Participants lie in the supine position with the FMS platform placed below the knee joint. Hip and knee position in the center; one leg is lifted while the other leg is kept in contact with the test board. After both legs are completed 3 times in a row, the score is recorded.

Trunk stability push-ups

The athlete stands in a prone position with feet together and hands shoulder-width apart. He brings the ankles to dorsiflexion while bringing the knees to full extension. Then, with the strength of the arm and abdominal muscles, it brings the body to the push-up position without any delay in the spine. Males start with their thumbs at the top of the forehead, while females start with their thumbs at the chin level.

Rotary stability

The athlete performed a quadrupedal position using the board in the FMS test kit. They then simultaneously raised and extended the arm and leg on the same side of their body.

Data Analysis

All data were analyzed on the computer using the SPSS (Statistical Package for Social Sciences) 26 program. Shapiro-Wilk test was used to decide the normality of the distribution and it was determined that the measured values did not show normal distribution by looking at the skewness-kurtosis coefficients of the data and the histogram, normal Q-Q plot and box-plots normal distribution curve. Those who did not show normal distribution were compared with the Man-Whitney U test in the comparison of two independent groups. The significance level of 0.05 was accepted as a criterion in interpreting whether the obtained values were significant or not.

RESULTS

According to Table 1, in order to determine whether the FMS measurement values obtained from the athletes show a normal distribution, Shapiro-Wilk test results and other indicators of normal distribution, histogram, normal Q-Q graph, and box-plots normal distribution curve, kurtosis skewness coefficients, and sample number are taken into consideration. It was decided that the data did not show normal distribution. The significance level of 0.05 was used as a criterion in interpreting whether the obtained values were significant or not.

Table 1. Findings Related to Normal Distribution of the Data

	Tests	Shapiro-Wilk			Skewness	Kurtosis
		Statistics	n	p		
Male	DSFS	0,30	14	0,00	0,30	-0,66
	HSS-R	0,64	14	0,00	-0,57	1,12
	HSS-L	0,65	14	0,00	-0,55	-0,01
	HSFS	0,52	14	0,00	-2,41	4,35
	ILS-R	-	14	-	0,46	-2,09
	ILS-L	-	14	-	0,15	-2,31
	ILFS	-	14	-	1,67	0,90
	SMS-R	0,81	14	0,01	-	-
	SMS-L	0,77	14	0,00	-	-
	SMFS	0,77	14	0,00	-	-
	ASLRS-R	0,65	14	0,00	0,26	-0,51
	ASLRS-L	0,58	14	0,00	-0,55	-0,39
	ASLRFS	0,65	14	0,00	0,31	-0,40
	TSPFS	-	14	-	-0,15	-2,31
	RSS-R:	0,30	14	0,00	-1,18	-0,73
	RSS-L:	-	14	-	-0,15	-2,31
	RSSFS	-	14	-	-3,87	15,00
Female	DSFS	0,64	8	0,00	0,77	2,43
	HSS-R	0,83	8	0,06	-0,30	0,02
	HSS-L	0,66	8	0,00	0,80	-0,20
	HSFS	0,83	8	0,06	-1,23	-0,84
	ILS-R	-	8	-	-0,60	-0,35
	ILS-L	-	8	-	-0,37	-2,80
	ILFS	-	8	-	-0,60	-0,35
	SMS-R	0,72	8	0,00	-	-
	SMS-L	0,42	8	0,00	-	-
	SMFS	0,72	8	0,00	-	-
	ASLRS-R	-	8		-1,76	2,36
	ASLRS-L	0,42	8	0,00	-2,65	7,00
	ASLRFS	0,42	8	0,00	-1,76	2,36
	TSPFS	0,57	8	0,00	-	-
	RSS-R:	-	8	-	-2,65	7,00
	RSS-L:	-	8	-	-2,65	7,00
	RSSFS	-	8	-	-2,65	7,00

DSFS (deep squad final score), HSS-R (hurdle Step score-right), HSS-L (hurdle step score-left), HSFS: (hurdle step final score), ILS-R (inline lunge score- right), ILS-L (inline lunge score- left), ILFS (inline lunge final score), SMS-R (shoulder mobilitiy score-right), SMS-L (shoulder mobilitiy score-left), SMFS (shoulder mobilitiy final score), ASLRS-R (active straight leg raise score-right) , ASLRS-L (active straight leg raise score-left), ASLRFS (active straight leg raise final score), TSPFS: (trunk stability push-ups final score), RSS-R (rotary stability score-right), RSS-L (rotary stability score-left), RSSFS (rotary stability score final score)

According to Table 2, the age of male athletes participating in the study is between 19-36, with an average of 26.79±5.16 years, while the age of female athletes is between 27-40, with an average of 32.38±3.74. The mean weight of male athletes is 80.36±7.34, while the weight of females is 59.63±5.95. The average height of the male athletes is 177.07±5.51 and the height of the females is 162.50±5.04.

Table 2. Descriptive Statistics of Some Measurements of Athletes

Tests	Male (n:14)				Female (n:8)			
	Min	Max	$\bar{X}$	SS	Min	Max	$\bar{X}$	SS
Age (year)	19	36	26,79	5,16	27	40	32,38	3,74
Weight (kg)	72	93	80,36	7,34	50	69	59,63	5,95
Height (cm)	170	185	177,1	5,51	157	172	162,5	5,04
FMS								
DSFS	2	3	2,93	0,27	2	3	2,63	0,52
HSS-R	2	3	2,43	0,51	1	3	2,25	0,71
HSS-L	2	3	2,50	0,52	2	3	2,50	0,53
HSFS	2	3	2,21	0,43	1	3	2,25	0,71
ILS-R	3	3	3,00	0,00	3	3	3,00	0,00
ILS-L	3	3	3,00	0,00	3	3	3,00	0,00
ILFS	3	3	3,00	0,00	3	3	3,00	0,00
SMS-R	1	3	1,79	0,70	1	3	2,50	0,76
SMS-L	1	3	2,36	0,63	2	3	2,88	0,35
SMFS	1	3	1,64	0,63	1	3	2,50	0,76
ASLRS-R	2	3	2,50	0,52	3	3	3,00	0,00
ASLRS-L	2	3	2,71	0,47	2	3	2,88	0,35
ASLRFS	2	3	2,50	0,52	2	3	2,88	0,35
TSPFS	3	3	3,00	0,00	2	3	2,75	0,46
RSS-R	2	3	2,07	0,27	2	2	2,00	0,00
RSS-L	2	2	2,00	0,00	2	2	2,00	0,00
RSSFS	2	2	2,00	0,00-	2	2	2,00	0,00
FMS-TS	15	20	17.28	1.27	16	20	18.0	1.31

DSFS (deep squad final score), HSS-R (hurdle Step score-right), HSS-L (hurdle step score-left), HSFS: (hurdle step final score), ILS-R (inline lunge score- right), ILS-L (inline lunge score- left), ILFS (inline lunge final score), SMS-R (shoulder mobilitiy score-right), SMS-L (shoulder mobilitiy score-left), SMFS (shoulder mobilitiy final score), ASLRS-R (active straight leg raise score-right) , ASLRS-L (active straight leg raise score-left), ASLRFS (active straight leg raise final score), TSPFS: (trunk stability push-ups final score), RSS-R (rotary stability score-right), RSS-L (rotary stability score-left), RSSFS (rotary stability score final score), $\bar{X}(ortalama)$, SS (standart deviation)

According to Table 3, the "Shoulder mobility right score" measurement values of the athletes show a statistically significant difference according to the gender of the athletes (Z=-2.07, p<0.05). "Shoulder mobility left score" measurement values of the athletes show a statistically significant difference according to the gender of the athletes (Z=-2.01, p<0.05). "Shoulder mobility final score" measurement values of the athletes show a statistically significant difference according to the gender of the athletes (Z=-2.44, p<0.05). Also, "Active straight leg raise right score" measurement values show a statistically significant difference according to the gender of the athletes in the comparison of the FMS measurements of the athletes by gender (Z=-2.37, p<0.05).

Table 3. Results of Comparison of All FMS Measurement Values of Athletes by Gender

Tests		n	$\bar{X} \pm SS$	Z	p
DSFS	M	14	2,93±0,27	-1,74	0,08
	F	8	2,63±0,52		
HSS-R	M	14	2,43±0,52	-0,54	0,59
	F	8	2,25±0,71		
HSS-L	M	14	2,5±0,52	0,00	1,00
	F	8	2,5±0,54		
HSFS	M	14	2,22±0,43	-0,29	0,77
	F	8	2,25±0,71		
ILSR	M	14	3±0	0,00	1,00
	F	8	3±0		
ILSL	M	14	3±0	0,00	1,00
	F	8	3±0		
ILFS	M	14	3±0	0,00	1,00
	F	8	3±0		
SMS-R	M	14	1,79±0,7	-2,07	**0,04***
	F	8	2,5±0,76		
SMS-L	M	14	2,36±0,64	-2,01	**0,04***
	F	8	2,88±0,36		
SMFS	M	14	1,65±0,64	-2,44	**0,01***
	F	8	2,5±0,76		
FMS-TS	M	14	17.28±1.27	0.30	0.22
	F	8	18.0±1.31		
ASLRS-R	M	14	2,5±0,52	-2,37	**0,02***
	F	8	3±0		
ASLRS-L	M	14	2,72±0,47	-0,85	0,40
	F	8	2,88±0,36		
ASLRFS	M	14	2,5±0,52	-1,72	0,09
	F	8	2,88±0,36		
TSPFS	M	14	3±0	-1,92	0,06
	F	8	2,75±0,47		
RSS-S	M	14	2,08±0,27	-0,76	0,45
	F	8	2±0		
RSS-L	M	14	2±0	0,00	1,00
	F	8	2±0		
RSFS	M	14	2±0	0,00	1,00
	F	8	2±0		

DSFS (deep squad final score), HSS-R (hurdle Step score-right), HSS-L (hurdle step score-left), HSFS: (hurdle step final score), ILS-R (inline lunge score- right), ILS-L (inline lunge score- left), ILFS (inline lunge final score), SMS-R (shoulder mobilitiy score-right), SMS-L (shoulder mobilitiy score-left), SMFS (shoulder mobilitiy final score), FMS-TS (functional movement screen- total score), ASLRS-R (active straight leg raise score-right) , ASLRS-L (active straight leg raise score-left), ASLRFS (active straight leg raise final score), TSPFS: (trunk stability push-ups final score), RSS-R (rotary stability score-right), RSS-L (rotary stability score-left), RSSFS (rotary stability score final score), $\bar{X}(ortalama)$, SS (standart deviation), M (male), F (female)

DISCUSSION

The aim of this study was to determine the types of injuries related to gender in high-intensity CrossFit exercises. When the FMS total scores were examined in the study, the score of the male CrossFit athletes was 17.28±1.27, while the score of the female CrossFit athletes was 18.0±1.31. Multiple studies reported that the total FMS score should be ≥ 14 for disability prevention (Kiesel et al. 2007; Chorba et al. 2010; Letafatkar et al. 2014; Bardenett, 2015). From this point of view, it can be said that the probability of injury of all athletes participating in the study is low because the FMS total scores of the female and male athletes in this study are above 14. Although Crossfit athletes are in the risk-free group according to their FMS scores, this does not indicate that there is no risk of injury. In a survey conducted with 424 people, 204 participants reported that they at least got injured once while doing Crossfit (Szajkowski et al. 2023), and the results showed that the shoulder and lumbar region were the regions with the highest number of injuries (Szajkowski et al. 2023).

Apart from the total scores, when the scores of 7 movements between the two genders were examined, it was observed that the highest scores were 'Inline Lunge' and 'Trunk stability push-ups' in males, and 'Inline Lunge' in females. It was observed that the lowest score belonged to the 'Shoulder mobility' test in men and the 'Rotary stability' test in females. In addition, when comparing the FMS scores of the athletes by gender, it was determined that there were significant differences between the two groups in the "Shoulder mobility right, left and final score", and "Active straight leg raise" scores. Female athletes have higher shoulder mobility scores than male athletes. Therefore, the results of this study by Szajkowski et al. (2023) show similarities with the results. Additionally, similar to our study, it has been reported in studies that male athletes are injured more often than female athletes (Shim et al. 2023; Weisenthal et al. 2014).

Conclusion

In this study, it was aimed to determine the types of injuries that may occur in CrossFit exercises based on gender, and as a result;

1. In the findings obtained, it was determined that the total FMS scores of the athletes who do CrossFit were above the average for both genders.

2. When evaluated according to gender, it was found that females had higher 'shoulder mobility' and 'active straight leg raising' scores compared to men on the basis of movement.

3. There was no statistically significant difference in terms of other parameters.

Conflict of Interest

The author declare no conflict of interest. No financial support was received.

Ethics Statement

The approval of the Ethics Committee of Hamidiye scientific research was obtained for the study (2023/15- 23/494).

Author Contributions

Study Design, YY; Data Collection, YY; Statistical Analysis, YY; Data Interpretation, YY; Manuscript Preparation, YY; Literature Search, YY.

REFERENCES

Bardenett, S.M., Micca, J.J., DeNoyelles, J.T., Miller, S.D., Jenk, D.T., Brooks, G.S. (2015). Functional movement screen normative values and validity in high school athletes: Can the FMS be used as a predictor of injury? *Int J Sports Phys Ther;*10(3):303-308.

Chorba, R.S., Chorba, D.J., Bouillon, L.E., Overmyer, C.O., Landis, J.A. (2010). Use of a functional movement screening tool to determine injury risk in female collegiate athletes. *N Am J Sports Phys Ther*. 5(2):47-54

Claudino, J.G., Gabbett, T.J., Bourgeois, F., et al. (2018). Crossfit overview: systematic review and meta-analysis. *Sports Med Open*; 26;4(1):11

Clifford, C. (2016). *The Founder Of Crossfit Credits His Success To One Simple Secret*. In: CNBC.

Cook, G., Burton, L., Hoogenboom, B. (2006). Pre-participation screening: the use of fundamental movements as an assessment of function - part 1. *N Am J Sports Phys Ther*;1:62–72.

Cook, G., Burton, M., Hoogenboom, B., Voight, M. (2014). Functional movement screening: the use of fundamental movements as an assessment of function. *Int J Sports Phys Ther;* 9(3):396-409.

Feito, Y., Heinrich, K. M., Butcher, S. J., and Poston, W. S. C. (2018). High-intensity functional training (HIFT): Definition and research implications for improved fitness. *Sports*; *6*(3):76.

Frost, D. M., Beach, T. A., Callaghan, J. P., And McGill, S. M. (2012). Using the Functional Movement Screen™ to evaluate the effectiveness of training. *The Journal of Strength & Conditioning Research*;*26*(6),1620-1630.

Gulgin, H., Hoogenboom, B. (2014). The functional movement screening (FMS)™: an inter-rater reliability study between raters of varied experience. *Int J Sports Phys Ther*; 9:14–20.

Kiesel, K.B., Plisky, P.J., Voight, M.L. (2007). Can serious injury in professional football be predicted by a preseason functional movement screen. *N Am J Sports Phys Ther*;2(3):147-158.

Letafatkar, A., Hadadnezhad, M., Shojaedin, S., Mohamadi, E. (2014). Relationship between functional movement screening score and history of injury. *Int J Sports Phys Ther;* 2014;9(1):21-27.

Needham, R.A., Chockalingam, N. (2015). The effect of an intervention program on functional movement screen test scores in mixed martial arts athletes. *J Strength Cond Res*;29:219–25.

Rodriguez, M.A., Garcia-Calleja, P., Terrados, N., Crespo, I., Del Valle, M., Olmedillas, H. (2021). Injury in CrossFit(R): a systematic review of epidemiology and risk factors. *Phys Sportsmed;* 1-8.

Sarıçam, H., Madan, M., And Soykan, A. (2022). The structure and culture of Crossfit as a fitness trend in Turkey.

Journal of Physical Education and Sports Sciences*;*24(1):16-22. Shim, S. S., Confino, J. E., Vance, D. D. (2023). Common orthopaedic injuries in crossfit athletes. *Journal of the American Academy of Orthopaedic Surgeons;*31 (11):557-564.

Stracciolini, A., Quinn, B., Zwicker, R. L., Howell, D. R., and Sugimoto, D. (2020). Part I: CrossFit-related injury characteristics presenting to sports medicine clinic. *Clinical Journal of Sport Medicine*; *30*(2):102-107.

Summitt, R.J., Cotton, R.A., Kays, A.C., Slaven, E.J. (2016). Shoulder injuries in individuals who participate in crossfit training. *Sports Health*; 8(6):541-546.

Szajkowski, S., Dwornik, M., Pasek, J., And Cieślar, G. (2023). Risk Factors for Injury in CrossFit®-A Retrospective Analysis. *International Journal of Environmental Research and Public Health;*20(3), 2211

Toledo, R., Dias, M.R., Souza, D., et al. (2021). Joint and muscle injuries in men and women CrossFit(R) training participants. *Phys Sportsmed*; 50:1–7.

Weisenthal, B.M., Beck, C.A., Maloney, M.D., DeHaven, K.E., Giordano, B.D. (2014). Injury rate and patterns among crossfit athletes. *Orthop J Sports Med;* 2(4):2325967114531177.