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COMPARATIVE ANALYSIS OF SOMATIC PARAMETERS AND MOVEMENT QUALITY IN NOVICE AND EXPERIENCED CROSSFIT ATHLETES

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Abstract In this study, fifty active CrossFit athletes were divided into beginner (n = 25, mean age 24.8 ±5.2 years) and experienced groups (n = 25, mean age 25.1 ±4.9 years) to assess injury risk, body fat distribution, and functional movement quality at different levels of experience. All participants attended training sessions five times a week and were preparing for competitions, training CrossFit at a competitive level, with the beginner group having up to 2 years of CrossFit training and the experienced group having 4–6 years of training experience. All participants attended training sessions five times a week and were preparing for competitions, training CrossFit at a competitive level. Both groups were evaluated for skinfold thickness and body fat percentage using appropriate measurement techniques, while functional movements were assessed separately using the Functional Movement Screen (FMS) Kit system and protocol. The results indicated that the experienced group demonstrated significantly higher overall FMS scores ($U = 71.5$, $p < 0.001$, $r = 0.67$), suggesting better functional movement patterns and potentially lower injury risk. They also exhibited higher body density and lower body fat percentages ($U = 126$, $p < 0.001$, $r = 0.51$) compared to the beginner group, which had higher skinfold thickness measurements in the breast, abdominal, and thigh areas. The findings of the study suggest that with increased experience in CrossFit training, athletes tend to have lower body fat, especially in the lower body, and exhibit improved functional movement quality. These improvements in movement efficiency potentially decrease the risk of injury, highlighting the benefits of long-term participation in high-intensity CrossFit training.

Key words: functional training, functional movement screen, body fat, injury risk

Introduction

The internet has played a significant role of CrossFit in making this program widely accessible, which has resulted in increased interest from individuals of all fitness levels (Kuhn, 2013). While the benefits of CrossFit are multifaceted and have been studied extensively, the safety of this high-intensity training method continues to be a subject of debate (Herz et al., 2015; Kuhn, 2013). Nevertheless, many studies have shown that CrossFit can lead to improved physical fitness, body composition, and overall health (Ballesta-García et al., 2019; Hamdouni et al., 2022; Moghimi Sarani, 2020). It is important for anyone looking to start CrossFit training to consider their physical condition and aptitude, as well as the need for proper nutrition, regularity, varied physical training, and adequate recover (Dawson, 2017; Kuhn, 2013). Overall, CrossFit has become a popular and effective training method for individuals looking to improve their physical fitness and functional capacity. CrossFit is a high-intensity training methodology that combines elements of weightlifting, gymnastics, and cardiovascular exercises to enhance overall fitness. It focuses on functional movements that mimic everyday activities, such as squatting, lifting, pushing, and pulling, which involve multiple muscle groups and improve functional strength and efficiency (Kuhn, 2013). CrossFit include daily Workouts of the Day (WODs), consisting of a warm-up, skill or strength work, and a main workout that can be a timed challenge, a set number of repetitions, or a combination of exercises. Exercises are scalable, allowing individuals of different fitness levels to participate and benchmark workouts are periodically repeated to measure progress (Leitão et al., 2021). CrossFit has been associated with an increased risk of injury due to its high-intensity nature and focus on functional movements, as the high intensity and variable pace can potentially lead to incorrect exercise technique and affect movement quality. Research has shown that injury rates in CrossFit are relatively high, especially for newcomers or those who have not been physically active for a while (Smith et al., 2013). However, studies also suggest that injury rates in CrossFit are similar to those in other high-intensity sports, such as running, weightlifting, and gymnastics. The Functional Movement Screen (FMS) can be used as a pre-participation tool to detect biomechanical anomalies in athletes caused by either a previous injury or abnormal movement patterns from training-intensity sports such as Olympic weightlifting and powerlifting (Weisenthal et al., 2014). Injuries in CrossFit often involve the shoulder, back, and knee, and may result from poor technique, overtraining, or lack of proper warm-up and cool-down routines (Smith et al., 2013). However, injury risk can be minimized by working with a qualified coach who emphasizes proper technique, gradually increasing the intensity and volume of training, and taking adequate rest and recovery time between workouts (Kaczorowska et al., 2020; Klimek et al., 2018). It is also important for individuals to listen to their bodies and avoid pushing themselves beyond their limits, as this can increase the risk of injury. CrossFit can be a safe and effective way to improve fitness and functional performance, but it is crucial to approach training with caution and respect for one's physical limitations (Herz et al., 2015).

The Functional Movement Screen (FMS) can be used as a pre-participation tool to detect biomechanical anomalies in athletes caused by either a previous injury or abnormal movement patterns from training (Cook et al., 2006a; Kiesel et al., 2007; Schneiders et al., 2011). The FMS can also be used to predict injury by finding a relationship between a low FMS score and the occurrence of injury. CrossFit athletes can be assessed using FMS to detect any movement abnormalities and asymmetries. CrossFit produces a clear symmetry in some fundamental movements compared to weightlifting and bodybuilding (Tafuri et al., 2016). Functional movement and anthropometric measurements, including FMS score, can predict athletic performance in different disciplines. Athletes with higher FMS scores and lower body fat levels performed better in the 100-meter swim (Bond et al., 2015). The FMS is an effective tool in determining the functional level of athletes at different levels of preparation in different disciplines (Bond et al., 2015). The study by Klimek et al. (2018) shows that CrossFit conducted in the right way does not affect the risk of injury as one might expect. More than 1,500 athletes at various levels of experience took part in the study, which gives great hope for the usefulness of CrossFit training.

Functional movement screening (FMS) has become an essential tool for assessing movement patterns, identifying biomechanical anomalies, and predicting injury risk in athletes. However, several factors can influence the FMS scores of an individual, including their age, gender, and body fat levels. Studies have shown that body fat levels and FMS scores can be associated with athletic performance. Bond et al. (Bond et al., 2015) found a high correlation between FMS score, body fat levels, and swimming speed in competitive swimmers of 100-meter swim. Similarly, a study by Campa et al. (2019) revealed that body fat levels had a negative impact on FMS scores in. Age can also be a factor in FMS scores. Wright & Chesterton (2018) suggested that testing young athletes aged 8–18 years for FMS may be unreliable due to the effects of puberty. However, Kuzuhara et al. (2018) found no correlation between age and FMS scores in mini-basketball players. Gender can also play a role in FMS scores. A study by Tafuri et al. (2016) compared CrossFit athletes' FMS scores to weightlifters and bodybuilders and found a high level of congruence in performance on bilateral tests. However, the study revealed that active straight leg lifting showed a lack of symmetry between the genders, with female athletes performing worse than male athletes. Additionally, Magyari et al. (Magyari 2017) found that female athletes had lower FMS scores than male athletes, indicating that gender may play a role in FMS scores. In conclusion, while FMS has proven to be an effective tool in assessing an athlete's movement patterns and injury risk, factors such as body fat levels, age, and gender should be taken into consideration when interpreting FMS scores. More research is needed to further explore the impact of these factors on FMS scores and develop appropriate protocols for using FMS in different age and gender groups of athletes.

Drawing on the evidence presented, CrossFit emerges as an effective way to improve physical fitness and functional capacity. However, due to its high intensity, there is a risk of injury. To reduce this risk, it is important to train carefully and be aware of one's physical limits. Using the Functional Movement Screen (FMS) can help assess an individual's readiness for CrossFit by identifying movement problems and predicting injury risk. With tools like FMS and guidance from experienced coaches, people can safely and effectively enhance their fitness through CrossFit. The main goal of this study is to examine the effects of CrossFit training on body composition and movement quality in athletes at different experience levels. Specifically, the study aims to:

1. Compare body fat percentage and skinfold measurements between novice and experienced CrossFit athletes.
2. Assess functional movement quality using the FMS in both groups.
3. Investigate the relationship between CrossFit experience and injury risk based on FMS scores.

Based on the literature and preliminary observations, this study hypothesizes that experienced CrossFit athletes will have lower body fat percentages, lower skinfold measurements, higher FMS scores indicating better movement quality and lower injury risk, and that there will be a negative correlation between years of CrossFit training and body fat percentage, as well as a positive correlation between training experience and FMS scores.

Material and Methods

Ethics statement

The study was conducted in accordance with the guidelines of the Declaration of Helsinki and approved by the Bioethics Committee of the Medical Chamber (Resolution No. 316 of 1 October 2020).

We involved fifty active male CrossFit athletes, divided into beginner and experienced groups, in our study. The athletes in the beginning group (n = 25, mean age 24.8 ±5.2 years) had no more than 2 years of training experience, while the athletes in the experienced group (n = 25, mean age 25.1 ±4.9 years) had between 4–6 years of training experience. All participants attended training sessions five times a week and were preparing for competitions, training CrossFit at a competitive level.

Body composition and movements parameter analysis

Fold Meter Electronic Body Mass Measurement Instrument.

We measured body fat and lean body mass levels using a device that determined body fat percentage and lean body mass levels by first assessing skin-fat fold measurements of the upper, middle, and lower body (chest, abdominal muscles, quadriceps). Before taking measurements, we entered body weight in kilograms, body height in centimeters, and age into the device. We measured skinfold thickness at each site three times and calculated the arithmetic mean. We calculated body fat mass using logarithmic indices and took measurements using a skinfold meter. Error in this method were estimated to be between 3–9% (Westerterp & Skowrońska, 2007). We incorporated these measurements into "Table 1" in the Results section, appearing in the second, third, and fourth positions, respectively.

Tanita Body Composition Analyzer

We assessed body composition using the TBF-310 foot-to-foot model, which provided a printout of measured impedance and calculated FM and FFM. Subjects were barefoot and in underwear during the assessment (Domingos et al., 2019). From the findings obtained through the electrical bioimpedance analyser, the percentage measurement of adipose tissue was employed. It was incorporated into "Table 1" within the Results section, appearing in the final position under the designation "Body fat [%]".

Functional Movement Screen test.

We conducted the study using the FMS Kit system and followed the FMS test protocol. Each participant performed three attempts of each of the seven tests according to the recommended instructions. The tests consisted of deep squat, hurdle step, in-line lunge, shoulder mobility assessment, active straight leg rise, trunk stability push up and rotational stability (Cook et al., 2006b, 2006a). Each of the seven tests is scored separately on a scale of 0 to 3 points. The maximum score for all tests is 21 points. Interpreting the results: a range of 18 to 21 indicates the subject's normal movement patterns and adequate motor control and proper ranges of mobility and stability in the joints. A range of 15 to 17 points indicates the appearance of functional asymmetry and compensation (Cook, 2010). In the analysis, the overall Functional Movement Screen (FMS) score was employed for comparison between groups. The individual conducting the FMS test is certified and has completed the original and patented FMS diagnostic course.

Reliability of Measurements

To ensure the consistency of our FMS (Functional Movement Screen) assessments, we included both intrarater and interrater reliability estimates. The intrarater reliability (ICC = 0.85) was based on repeated assessments by the same evaluator over time, confirming consistent scoring within the same rater (Cook et al., 2006a). The interrater reliability (ICC = 0.75) was derived from assessments by different evaluators, ensuring that different raters provided consistent scores for the same athletes (Cook et al., 2006b). Additionally, the reliability for skinfold measurements was reported as ICC = 0.90 in previous studies (Westerterp & Skowrońska, 2007). Furthermore, the Tanita TBF-310 body composition analyzer demonstrated a reliability index of ICC = 0.92, ensuring consistent body fat percentage measurements (Domingos et al., 2019). These reliability estimates affirm the robustness and consistency of our assessment methods, providing confidence in the accuracy and reproducibility of our measurements.

Statistical Analysis

We used the Mann-Whitney U test to analyze the significance of differences between groups. We analyzed the collected data using StatsCloud software (https://statscloud.app/beta/). We determined the size of the intervention group using the GPower 3.1.9.2 program. With a total sample size of 50 persons in each of the 2 groups, we detected an effect size (0.71) with 80% power and a 5% significance level.

Results

We found that the experienced stage group had higher total scores than the beginning stage group. A Mann-Whitney U test revealed this difference as statistically significant (U = 71.5, p < 0.001, r = 0.67). Our analysis also demonstrated that all body composition parameters were statistically significantly different between the study groups.

The beginning stage group had statistically significantly higher scores than the experienced stage group for breast fold (U = 198, p = 0.025, r = 0.32), abdominal fold (U = 157, p = 0.002, r = 0.43), thigh fold (U = 165.5, p = 0.004, r = 0.41), and body fat (U = 126, p < 0.001, r = 0.51).

We observed that the experienced stage group had higher scores for body density than the beginning stage group (U = 157.5, p < 0.001, r = 0.48).

Table 1. Table of results for statistical significance of differences in individual parameters between experienced vs beginners group

Group			Test statistics		
Outcome	Predictor	Group	U	z	p
Total score	Stage	Beginners Experienced	71.5	–4.765	< 0.001
Chest fold (mm)	Stage	Beginners Experienced	198.0	–2.249	0.025
Abdominal fold (mm)	Stage	Beginners Experienced	157.0	–3.025	0.002
Thigh fold (mm)	Stage	Beginners Experienced	165.5	–2.866	0.004
Body density (g/cm3)	Stage	Beginners Experienced	157.5	–3.399	< 0.001
Body fat (%)	Stage	Beginners Experienced	126.0	–3.62	< 0.001

Discussion

The study investigated differences in physical fitness and body composition between beginning and experienced stage male CrossFit athletes. Our results indicate significant statistical differences between the two groups for several measures. The beginning stage group had significantly higher scores for breast fold, abdominal fold, and thigh fold compared to the experienced stage group, suggesting more body fat in these areas. This difference may be due to the varying levels of training experience between the beginner and experienced athletes. Conversely, the experienced stage group had significantly higher scores for body density and total FMS score, suggesting a lower body fat percentage and better functional movement patterns. This could result from more intensive and specific training to improve physical fitness and performance in the experienced stage group.

FMS, designed to assess functional movements and injury risk, is crucial in CrossFit diagnostics. CrossFit's impact on biomechanics varies with age and fitness levels, making it essential to assess its effects at different life stages. FMS requires selecting an age-appropriate group; scores may be unreliable in adolescents (Wright & Chesterton, 2018). Montalvo et al. (2017) found higher FMS scores in experienced CrossFit athletes compared to novices, consistent with our study. Similarly, Davis et al. (Davis et al., 2020) found a positive association between higher FMS scores and better physical performance in soldiers. Moore et al. (2019) noted mixed results on FMS scores and injury risk, suggesting higher FMS scores might indicate lower injury risk, though further research is needed.

Comparing the results with Perna et al. (2018) have different research designs and aims. The above research is a cross-sectional study comparing two groups of CrossFit athletes at a single point in time, while Perna et al. (2018) research is a pre-post trial evaluating the effects of different training interventions of CrossFit on body composition markers. Additionally, the measurements used in each result differ, with Methods in this article using skinfold thickness and body density measurements, while Perna et al. (2018) used DXA to measure body composition. Despite these differences, both results show that body composition can be significantly affected by different factors such as stage of training and type of high-intensity training. This suggests that individuals and trainers should consider these factors when designing and implementing training programs. Study of Smith et al. (2013) describe a study that aimed to investigate the effects of CrossFit training on cardiovascular risk factors in overweight men. The study compared two groups, the CrossFit group, and the control group. The CrossFit group showed significant improvements inter alia for weight, BMI, body fat percentage compared to the control group. However, no significant differences were observed between the two groups for waist, hip and thigh circumferences, waist-hip ratio. Looking for similarities both studies involved comparing different groups, they differ in their specific focus and outcome measures. Above studies aimed to compare the body composition measures between two different groups of athletes, whereas Smith et al. (2013) focused on the effects of CrossFit training on cardiovascular risk factors in overweight men and provides a wider range of measures including body composition, physical fitness, and lipid profile. The results of the study Menargues-Ramirez et al. (2022) on anthropometric characteristics of CrossFit athletes suggest that having low fat mass and high muscle mass can benefit an athlete's performance in this sport. This finding is consistent with the notion that CrossFit involves a combination of strength and cardiovascular exercises and having a low body fat percentage and high muscle mass can help athletes perform well in both areas. Interestingly, the study (Menargues-Ramírez, 2022) found that the physical demands of lifting heavy loads in CrossFit resulted in athletes having anthropometric values similar to elite weightlifting athletes than in other sports. This highlights the importance of strength training in CrossFit, and how it can have a significant impact on an athlete's body composition and performance. In comparison, both studies highlight the importance of body composition in athletic performance and how training can influence it. In the context of CrossFit, having a low body fat percentage and high muscle mass can be advantageous for athletes, while training can lead to changes in body composition over time.

Our findings reveal significant differences between beginning and experienced stage athletes, with the latter group exhibiting lower body fat percentages, better functional movement patterns, and higher FMS scores. These differences could be attributed to the advanced training and practice of experienced stage athletes. Furthermore, the relationship between FMS scores and injury risk remains inconclusive, warranting further investigation. Similarities between these studies and those by Smith et al. (2013) and Menargues-Ramirez et al. (2022) demonstrate the impact of CrossFit training on various aspects of physical fitness and body composition. CrossFit athletes may benefit from low body fat percentages and high muscle mass, as these factors can positively influence performance in both strength and cardiovascular exercises. Overall, these findings underscore the importance of considering factors such as training stage and intensity when designing and implementing training programs for CrossFit athletes. A comprehensive understanding of body composition and physical fitness in relation to performance can help trainers and athletes optimize their training approach and achieve better results.

This study is novel in that it provides a detailed analysis of the long-term impact of CrossFit training on somatic parameters and functional movement quality. Our findings highlight the significant differences in body composition and functional movement between novice and experienced CrossFit athletes, emphasizing the importance of advanced training. However, this study has several limitations that should be considered when interpreting the findings. FMS relies heavily on the subjective judgment of examiners, which can introduce variability in scoring due to individual interpretation differences. Additionally, the 0–3 scoring system used in FMS lacks granularity, making it less effective at distinguishing subtle differences in performance and movement quality among athletes of varying skill levels. Furthermore, the reliance on skinfold measurements for assessing body composition, although generally reliable, is also subject to the technique and experience of the evaluator, which can introduce potential errors. Despite high interrater reliability reported for these measurements (ICC = 0.90) (Westerterp & Skowrońska, 2007), subjective error remains a concern. These limitations suggest that while our findings offer valuable insights into the differences between beginning and experienced CrossFit athletes, they should be interpreted with caution. Addressing these issues in future research will help provide more definitive conclusions and better support the development of effective training programs for CrossFit athletes.

Conclusions

This study enhances our understanding of the differences in body composition and physical fitness between novice and experienced CrossFit athletes. Our findings demonstrate that experienced CrossFit athletes have lower body fat percentages, better functional movement patterns, and higher FMS scores compared to novice athletes. These differences can be attributed to the advanced training and practice of experienced athletes, highlighting the significant impact of CrossFit training on physical fitness and body composition. These results underscore the importance of personalized CrossFit training programs, taking into consideration the athlete's training stage and intensity. By focusing on these factors, trainers can optimize training approaches to improve performance and reduce injury risks. This study contributes valuable insights that can aid in the development of more effective and individualized training regimens for CrossFit athletes.

Supplementary Materials

Table 2. Results of the FMSTM test of athletes at the beginning stage

Number of athletes	Test 1	Test 2	Test 3	Test 4	Test 5	Test 6	Test 7	Total Score
Athlete 1	3	2	2	3	2	3	2	17
Athlete 2	3	2	3	2	2	3	2	17
Athlete 3	2	2	3	0	2	3	2	14
Athlete 4	2	2	3	2	2	3	2	16
Athlete 5	3	2	2	3	2	3	2	17
Athlete 6	3	2	3	3	3	3	2	19
Athlete 7	2	2	3	3	3	3	2	18
Athlete 8	2	2	3	0	2	3	3	15
Athlete 9	2	2	3	0	2	3	2	14
Athlete 10	2	2	2	2	1	3	2	14
Athlete 11	2	2	3	3	2	3	2	17
Athlete 12	2	2	2	3	2	0	2	13
Athlete 13	2	3	3	2	2	3	2	17
Athlete 14	1	2	2	3	2	3	2	15
Athlete 15	3	2	3	3	2	3	2	18
Athlete 16	2	2	2	2	2	2	1	13
Athlete 17	3	2	3	3	3	3	2	19
Athlete 18	3	2	2	3	2	3	2	17
Athlete 19	3	2	2	2	2	2	2	15
Athlete 20	3	2	2	3	2	3	2	17
Athlete 21	3	3	3	3	2	3	2	19
Athlete 22	2	2	3	3	2	3	2	17
Athlete 23	2	3	2	2	2	3	2	16
Athlete 24	3	2	3	1	2	2	2	15
Athlete 25	2	2	2	3	2	2	2	15

Table 3. Results of the FMSTM test of athletes at the expierienced stage

Number of Athletes	Test 1	Test 2	Test 3	Test 4	Test 5	Test 6	Test 7	Total Score
Athlete 1	3	3	3	3	3	3	2	20
Athlete 2	3	2	3	3	2	3	2	18
Athlete 3	3	2	3	3	2	3	2	18
Athlete 4	3	3	3	2	2	3	2	18
Athlete 5	3	2	3	3	2	3	2	18
Athlete 6	3	3	3	3	3	3	2	20
Athlete 7	3	2	3	2	3	3	2	18
Athlete 8	3	3	3	2	3	3	2	19
Athlete 9	3	2	3	3	2	3	2	18
Athlete 10	3	2	3	3	2	3	2	18
Athlete 11	3	2	3	3	2	3	2	18
Athlete 12	3	2	3	3	3	3	2	19
Athlete 13	3	3	3	3	3	3	2	20
Athlete 14	3	3	3	3	2	3	2	19
Athlete 15	3	3	3	3	3	3	3	21
Athlete 16	3	2	3	2	2	3	1	17
Athlete 17	3	2	3	3	3	3	2	19

Number of Athletes	Test 1	Test 2	Test 3	Test 4	Test 5	Test 6	Test 7	Total Score
Athlete 18	3	3	3	3	2	3	2	19
Athlete 19	3	3	3	2	3	3	2	19
Athlete 20	3	3	2	3	2	3	2	18
Athlete 21	3	2	3	3	3	3	2	19
Athlete 22	3	2	3	3	3	3	2	19
Athlete 23	3	2	2	3	3	3	2	18
Athlete 24	3	3	3	2	3	3	2	19
Athlete 25	3	2	3	2	2	3	2	17

Table 4. Results of the skinfold measurements and body fat of athletes at the beginning stage

Number of Athletes	(mm) Thoracic fold	(mm) Abdominal fold	(mm) Thigh fold	(g/cm3) Body density	(%) Body fat
Athlete 1	12	19	12	1,07	12.79
Athlete 2	16	27	14	1,06	16.41
Athlete 3	9	18	15	1,07	12.07
Athlete 4	17	38	35	1,04	25.13
Athlete 5	19	22	24	1,05	18.47
Athlete 6	8	23	21	1,06	15.3
Athlete 7	8	13	19	1,07	11.72
Athlete 8	6	28	27	1,05	17.76
Athlete 9	8	18	11	1,07	10.89
Athlete 10	9	2	16	1,08	8.24
Athlete 11	11	23	11	1,06	13.82
Athlete 12	8	22	25	1,06	16.09
Athlete 13	8	24	16	1,06	14.22
Athlete 14	10	14	22	1,06	13,16
Athlete 15	14	20	12	1,06	13.37
Athlete 16	10	18	14	1,07	12.58
Athlete 17	9	18	20	1,06	13.95
Athlete 18	7	16	12	1,07	10.02
Athlete 19	6	11	12	1,07	9.25
Athlete 20	8	27	18	1,06	15.46
Athlete 21	9	18	15	1,07	12.17
Athlete 22	11	11	15	1,07	10.99
Athlete 23	10	19	18	1,06	13.64
Athlete 24	9	15	20	1,06	13.44
Athlete 25	12	25	21	1,05	17.09

Table 5. Results of the skinfold measurements and body fat of athletes at the experienced stage

Number of Athletes	(mm) Thoracic fold	(mm) Abdominal fold	(mm) Thigh fold	(g/cm3) Body density	(%) Body fat
Athlete 1	11	9	11	1.07	9.19
Athlete 2	8	25	12	1.06	13.51
Athlete 3	5	17	17	1.07	11.24
Athlete 4	4	16	14	1.07	10.04
Athlete 5	8	15	20	1.07	12.45
Athlete 6	7	14	17	1.07	11.17
Athlete 7	9	19	9	1.07	11.29

Number of Athletes	(mm) Thoracic fold	(mm) Abdominal fold	(mm) Thigh fold	(g/cm3) Body density	(%) Body fat
Athlete 8	7	12	18	1.07	11.29
Athlete 9	4	8	3	1.08	5.11
Athlete 10	7	12	15	1.07	10.14
Athlete 11	6	13	9	1.08	8.83
Athlete 12	8	12	12	1.07	9.68
Athlete 13	10	16	11	1.07	11.29
Athlete 14	9	17	12	1.07	11.17
Athlete 15	9	18	17	1.06	13.03
Athlete 16	8	15	10	1.07	10.27
Athlete 17	7	14	15	1.07	11.32
Athlete 18	11	21	11	1.07	12.86
Athlete 19	6	17	17	1.07	11.72
Athlete 20	9	18	18	1.06	13
Athlete 21	9	16	12	1.07	10.99
Athlete 22	12	11	11	1.07	10.25
Athlete 23	10	13	15	1.07	11.17
Athlete 24	8	13	17	1.07	11.47
Athlete 25	9	15	9	1.07	10.16

References

Ballesta-García, I., Martínez-González-Moro, I., Rubio-Arias, J., & Carrasco-Poyatos, M. (2019). High-intensity interval circuit training versus moderate-intensity continuous training on functional ability and body mass index in middle-aged and older women: A randomized controlled trial. *International Journal of Environmental Research and Public Health*, *16*(21), Article 4205. https://doi.org/10.3390/ijerph16214205

Bond, D., Goodson, L., Oxford, S. W., Nevill, A. M., & Duncan, M. J. (2015). The association between anthropometric variables, functional movement screen scores and 100 m freestyle swimming performance in youth swimmers. *Sports*, *3*(1), 1–11. https://doi.org/10.3390/sports3010001

Campa, F., Piras, A., Raffi, M., & Toselli, S. (2019). Functional movement patterns and body composition of high-level volleyball, soccer, and rugby players. *Journal of Sport Rehabilitation*, *28*(7), 740–745. https://doi.org/10.1123/jsr.2018-0087

Cook, G., Burton, L., & Hoogenboom, B. (2006a). Pre-participation screening: the use of fundamental movements as an assessment of function - part 1. *North American Journal of Sports Physical Therapy : NAJSPT*, *1*(2), 62–72.

Cook, G., Burton, L., & Hoogenboom, B. (2006b). Pre-participation screening: the use of fundamental movements as an assessment of function - part 2. *North American Journal of Sports Physical Therapy : NAJSPT*, *1*(3), 132–139.

Cook, G. (2010). *Movement: Functional movement systems: Screening, assessment and corrective strategies* (2nd ed.). On Target Publications.

Davis, J. D., Orr, R., Knapik, J. J., & Harris, D. (2020). Functional Movement Screen (FMS™) Scores and Demographics of US Army Pre-Ranger Candidates. *Military Medicine*, *185*(5–6), e718–e724. https://doi.org/10.1093/milmed/usz373

Dawson, M. C. (2017). CrossFit: Fitness cult or reinventive institution? *International Review for the Sociology of Sport*, *52*(3), 361–379. https://doi.org/10.1177/1012690215591793

Domingos, C., Matias, C. N., Cyrino, E. S., Sardinha, L. B., & Silva, A. M. (2019). The usefulness of Tanita TBF-310 for body composition assessment in Judo athletes using a four-compartment molecular model as the reference method. *Revista Da Associacao Medica Brasileira*, *65*(10), 1283–1290 https://doi.org/10.1590/1806-9282.65.10.1283

Hamdouni, H., Kliszczewicz, B., Zouhal, H., Rhibi, F., Ben Salah, F. Z., & Ben Abderrahman, A. (2022). Effect of three fitness programs on strength, speed, flexibility and muscle power on sedentary subjects. *Journal of Sports Medicine and Physical Fitness*, *62*(1), 132–139. https://doi.org/10.23736/S0022-4707.21.12086-9

Herz, J. C., Morais, D. G., & Todd, J. (2015). Learning to Breathe Fire: The Rise of CrossFit and the Primal Future of Fitness. *Sport Management Review*, *18*(4), 491–493. https://doi.org/10.1016/j.smr.2014.11.007

Kaczorowska, A., Noworyta, K., Mroczek, A., & Lepsy, E. (2020). Effect of the mobilityWOD training program on functional movement patterns related to the risk of injury in crossfit practitioners. *Acta Gymnica*, *50*(1), 1–10. https://doi.org/10.5507/ag.2020.002

Kiesel, K., Plisky, P. J., & Voight, M. L. (2007). Can Serious Injury in Professional Football be Predicted by a Preseason Functional Movement Screen? *North American Journal of Sports Physical Therapy : NAJSPT*, *2*(3), 147–158.

Klimek, C., Ashbeck, C., Brook, A. J., & Durall, C. (2018). Are injuries more common with CrossFit training than other forms of exercise? *Journal of Sport Rehabilitation*, *27*(3), 295–299. https://doi.org/10.1123/jsr.2016-0040

Kuhn, S. (2013). *The culture of CrossFit: A lifestyle prescription for optimal health and fitness* (Senior thesis, Illinois State University). Illinois State University. https://ir.library.illinoisstate.edu/sta/1

Kuzuhara, K., Shibata, M., Iguchi, J., & Uchida, R. (2018). Functional Movements in Japanese Mini-Basketball Players. *Journal of Human Kinetics*, *61*(1), 135–142. https://doi.org/10.1515/hukin-2017-0128

Leitão, L., Dias, M., Campos, Y., Vieira, J. G., Sant'ana, L., Telles, L. G., Tavares, C., Mazini, M., Novaes, J., & Vianna, J. (2021). Physical and physiological predictors of fran crossfit® wod athlete's performance. *International Journal of Environmental Research and Public Health, 18*(8), Article 4070. https://doi.org/10.3390/ijerph18084070

Magyari, N., Szakács, V., Bartha, C., Szilágyi, B., Galamb, K., Magyar, M. O., Hortobágyi, T., Kiss, R. M., Tihanyi, J., & Négyesi, J. (2017). Gender may have an influence on the relationship between Functional Movement Screen scores and gait parameters in elite junior athletes – A pilot study. *Physiology International*, *104*(3), 231–242. https://doi.org/10.1556/2060.104.2017.3.1

Menargues-Ramírez, R., Sospedra, I., Holway, F., Hurtado-Sánchez, J. A., & Martínez-Sanz, J. M. (2022). Evaluation of body composition in CrossFit® athletes and the relation with their results in official training. *International Journal of Environmental Research and Public Health, 19*(17), Article 11003. https://doi.org/10.3390/ijerph191711003

Moghimi Sarani, A. (2020). CrossFit training improves blood lipid profile in overweight men: A randomized controlled trial. *Journal of Physical Activity and Hormones* , *4*(1), 17–28.

Montalvo, A. M., Shaefer, H., Rodriguez, B., Li, T., Epnere, K., & Myer, G. D. (2017). Retrospective injury epidemiology and risk factors for injury in CrossFit. *Journal of Sports Science and Medicine*, *16*(1), 53–59.

Moore, E., Chalmers, S., Milanese, S., & Fuller, J. T. (2019). Factors Influencing the Relationship Between the Functional Movement Screen and Injury Risk in Sporting Populations: A Systematic Review and Meta-analysis. In *Sports Medicine, 49*(9), 1449–1463. https://doi.org/10.1007/s40279-019-01126-5

Perna, S., Bologna, C., Agosti, I. D., & Rondanelli, M. (2018). High intensity crossfit training compared to high intensity swimming: A pre-post trial to assess the impact on body composition, muscle strength and resting energy expenditure. *Asian Journal of Sports Medicine*, *9*(1), Article e13843– https://doi.org/10.5812/asjsm.13843

Schneiders, A. G., Davidsson, A., Hörman, E., & Sullivan, S. J. (2011). Functional movement screen normative values in a young, active population. *International Journal of Sports Physical Therapy*, *6*(2), 75–82.

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. In *Journal of Strength and Conditioning Research, 27*(11), 3159–3172. https://doi.org/10.1519/JSC.0b013e318289e59f

Tafuri, S., Notarnicola, A., Monno, A., Ferretti, F., & Moretti, B. (2016). Crossfit athletes exhibit high symmetry of fundamental movement patterns. A cross-sectional study. *Muscles, Ligaments and Tendons Journal*, *6*(1), 157–160. https://doi.org/10.11138/mltj/2016.6.1.157

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

Westerterp K. R., & Skowrońska U. (2007). *Skład ciała i jego pomiary, red. Sobotka L., Podstawy żywienia klinicznego: Vol. PZWL*.

Wright, M. D., & Chesterton, P. (2018). Functional Movement ScreenTM total score does not present a gestalt measure of movement quality in youth athletes. *Journal of Sports Sciences, 36(22), 2521–2527. https://doi.org/10.1080/02640414.2018.1465724*

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