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Normative Scores for CrossFit® Open Workouts: 2011–2022

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Abstract: To create normative scores for all CrossFit® Open (CFO) workouts and compare male and female performances, official scores were collected from the official competition leaderboard for all competitors of the 2011–2022 CFO competitions. Percentiles were calculated for athletes (18–54 years) who completed all workouts within a single year 'as prescribed' and met minimum scoring thresholds. Independent t-tests revealed significant ($p < 0.05$) sex differences for 56 of 60 workouts. In workouts scored by repetitions completed, men completed more repetitions in 18 workouts by *small* to *large* differences (d = 0.22–0.81), whereas women completed more repetitions in 6 workouts by *small* to *medium* differences (d = 0.36–0.77). When workouts were scored by time to completion, men were faster in 10 workouts by *small* to *large* differences (d = 0.23–1.12), while women were faster in 3 workouts by *small* differences (d = 0.46). In three workouts scored by load lifted, men lifted more weight by *large* differences (d = 2.00–2.98). All other differences were either *trivial* or not significant. Despite adjusted programming for men and women, the persistence of performance differences across all CFO workouts suggests that resultant challenges are not the same. These normative values may be useful for training and research in male and female CrossFit® athletes.

Keywords: fitness assessment; sport specific; athlete classification; high-intensity functional training; sex differences

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1. Introduction

The CrossFit® Open (CFO) has been the initial qualifying round for the CrossFit Games™ competition since 2011 [1]. It has typically consisted of 3–6 workouts that variably challenge some aspect related to an athlete's strength, endurance, sport-specific skill, or a combination of these [2,3]. Heading into the competition each year, athletes are aware of the number of weeks the CFO will last (3–5 weeks) but are unaware of each workout's specific details until they are individually released via online broadcast each Thursday evening. Since competitors are only given four days to complete a given week's workout and submit their best score to competition officials [3], they should ideally be prepared for all possibilities.

It is known that each CFO battery will consist of a unique set of workouts, all formatted to produce a score that readily distinguishes performance [2,3]. Athletes have been challenged with completing a list of exercises as quickly as possible and were ranked by time to completion (TTC), and at times, the TTC of certain tie-breaking criteria. Approximately 90% of TTC-style workouts have also been assigned a time limit [2,3], and for these, athletes who did not finish all the workout when the time expired were scored by the number of repetitions they completed. The most common format, however, assigned a list of exercises to be completed for 'as many repetitions as possible' (AMRAP) within a time limit, and athletes were ranked by the total number of repetitions they completed. Out of the 60 scored CFO workouts programmed between 2011 and 2022, 35 have been AMRAP-style events. Very rarely (~5% of CFO workouts), athletes were tasked with finding their one-repetition

maximum (1-RM) in a single exercise or complex within a time limit, and performance was based on load lifted.

Although CFO workouts might be limited in structure, and workouts have consistently included certain exercises from year to year, there are infinite possible exercise–prescription combinations. Each combination may uniquely challenge one or more energy systems and require different degrees of technical skill as well as strength and power. The CFO is indeed an accurate representation of the CrossFit® ideology which aims for simultaneous improvements in all areas of fitness [4]. In support of this, most investigated measures of body composition [5–7], strength and power [6,8–10], and aerobic and anaerobic capacity [5,6,8–12] have been related to performance. Athletes might use normative scores for many of these traditional physiological measures to estimate their ability to perform in competition [13]. However, the reported relationships have not demonstrated a hierarchal order of importance, and this is likely because they were not founded upon consistency. Sample populations, methods used for collecting physiological measures, and the workouts used to define performance have all varied across studies, leaving little clarity as to which laboratory-based measures should be monitored during training to predict competition performance. Further, it may not be practical or logistically feasible for non-researchers to acquire the expensive equipment (e.g., metabolic cart, cycle ergometers, force plates) needed to perform many traditional assessments. Standardized methods require varying degrees of expertise, are not always conducive for testing large groups, and are likely to impair movement and transitions if the desire is to measure responses during a typical CrossFit® workout.

Another solution may be to utilize CrossFit®-style workouts themselves to track progress and predict competition performance. Logically, performing well in these workouts during training or competition should be a strong predictor of future CFO performances. Indeed, past rankings at various stages of the CrossFit Games™ competitions have been shown to be indicative of 2020 CFO performance [14], and self-reported scores in benchmark workouts have also been shown to variably distinguish performance in 2016 [15] and 2018 [6] CFO competitors. Typically, any exercise and prescription combination could be programmed on any given training day [4], and this lack of consistency is problematic for tracking progress. However, benchmark workouts are unique because they are readily identified by their name (e.g., Fran, Grace, Murph) and their prescription is standard. After their initial introduction, CFO workouts become benchmark workouts and may periodically be programmed into normal training and have even reappeared in later CFO competitions [2,16]. By monitoring their performance in these workouts, and relating it to a specific percentile rank, athletes might gauge how they would perform in future CFO competitions.

Thus far, normative scores have only been published for five benchmark workouts (i.e., Grace, Fran, Helen, Fight-Gone-Bad, and Filthy-50) [17]. These were chosen because CFO athletes are able to self-report their performances for these specific workouts to their user profile on the official CrossFit Games™ leaderboard [18]. However, because scores are self-reported, performances are not verified, and scores may be updated at any time, their veracity and timeliness are questionable. In contrast, CFO workout performances must meet specific criteria to appear on the leaderboard [3,18]. For instance, athletes must either complete the workout at a CrossFit®-affiliated gym or in front of a judge who has passed the judges' certification course and who certifies that the athlete met all workout requirements and movement standards. Alternatively, athletes may submit a video recording of their performance using specific filming criteria and competition officials perform the judge's task. Because submissions are only accepted, validated, and ranked if they are received within the 4-day window following each workout's release, confidence in their accuracy and timeliness is much higher. While each competitor receives an official rank (absolute and percentile) for each validated submission, the separation between scores of neighboring percentile ranks is not made clear. Workout percentile ranks may also vary weekly for reasons other than differences in workout prescription, for example, as specialists, scaled

athletes, and injured athletes join or leave the main competition (i.e., report or fail to submit their scores). Therefore, the purpose of this study was to create normative scores for all existing CFO workouts (i.e., from 2011 to 2022) using official scores of competitors who completed each workout as prescribed (i.e., Rx) within each respective competition year. Additionally, because workouts are most often programmed differently between men and women, a secondary aim was to examine sex differences in the performance of each workout.

2. Materials and Methods

2.1. Experimental Design

Performance data were collected for all athletes participating in CFO competitions from 2011 to 2022. All competition results were obtained from the JSON file located on the publicly available, official competition leaderboard [19]. Python3 was used to convert the data into a CSV format, and the data were treated in Microsoft Excel (v. 365, Microsoft Corporation, Redmond, VA, USA). Since these data were pre-existing and publicly available, the University's Institutional Review Board classified this study as exempt, which did not require athletes to provide their informed consent (IRB #16-215). Treating the data involved removing all age-group athletes (e.g., teens and masters) and cases that did not meet study inclusion criteria. The retained data included each athlete's age and final overall ranking (within a given year), as well as their rank and score for every CFO workout that they completed.

2.2. Participants

From 2011 to 2022, total CFO participation ranged between 13,127 and 399,538 combined male and female athletes [19]. The entire population for each year included all Rx, scaled, and adaptive athletes from each age grouping, as well as athletes who registered for the competition but did not submit scores for any workouts. For this study, age, rank, and workout performance data (rank and score) were retained for all athletes between the ages of 18 and 54 years (i.e., non-age-group athletes) who completed all CFO workouts as prescribed (i.e., as Rx with no within-sex scaling) within a specific competition year. To limit the inclusion of workout "specialists" and those who did not intend on completing or could not perform the exercises for the Rx workout (e.g., when an athlete completed only a few repetitions of an Rx workout to boost their overall ranking), cases were excluded if any of their scores did not surpass a minimum threshold within a single competition year. The minimum thresholds defined for this study required athletes to complete:

1. At least one round (in AMRAP-style workouts);
2. The first exercise couplet in workouts where couplets were repeated;
3. All repetitions assigned for the first exercise in the list (TTC workouts) or when several rounds were not expected (in AMRAP-style workouts);
4. Timed workouts within 60 min when no time limit was programmed (i.e., CFO 14.5, CFO 15.5, and CFO 16.5);
5. A 1-RM with a load equal to or greater than the standard barbell used by men (45 lbs. (20.4 kg)) and women (35 lbs. (15.9 kg)).

Treating the data set with these criteria produced the total study population for each CFO year. Then, to minimize the effect of reporting or validation errors (intentional or non-intentional), random samples of approximately 68% of athletes from each study population (i.e., equal to approximately $\pm$ 1 standard deviation (SD)) [20] were drawn and retained for statistical analyses. Table 1 provides a summary of the initial population of athletes for each year, the number of cases meeting study criteria, and the age and final competition ranking characteristics of each final sample.

Table 1. Population and sample characteristics.

	Women					Men				
Year	**N_{Total}**	**N_{Study}**	***n***	**Age (y)**	**Rank (Range)**	**N_{Total}**	**N_{Study}**	***n***	**Age (y)**	**Rank (Range)**
2011	4506	3046	2084	30.3 ± 6.4	2039 ± 1242 (1–4491)	8621	7046	4764	29.6 ± 6.3	4089 ± 2468 (1–8619)
2012	14,217	8621	9715	30.8 ± 5.8	4574 ± 2869 (3–12,089)	25,027	18,873	25,146	30.6 ± 5.8	9776 ± 5861 (1–21,861)
2013	32,643	14,144	5864	31.3 ± 6.9	8008 ± 5389 (1–25,127)	52,169	36,808	12,852	31.6 ± 7.1	19,177 ± 11,500 (1–45,181)
2014	52,076	36,863	18,174	31.1 ± 7	14,668 ± 9520 (1–42,021)	80,284	63,828	43,371	31.8 ± 7.2	32,570 ± 19,137 (1–70,402)
2015	108,764	7787	5313	29.7 ± 6.1	5000 ± 3866 (3–22,769)	153,272	45,615	31,006	30.7 ± 6.6	24,568 ± 15,552 (1–66,148)
2016	130,154	16,372	11,135	30.4 ± 6.4	9875 ± 7042 (1–35,593)	178,510	53,920	36,662	31.3 ± 6.7	28,396 ± 17,509 (1–76,110)
2017	159,563	36,721	25,096	31.8 ± 7.1	20,299 ± 13,286 (1–63,069)	214,519	84,669	57,311	32.6 ± 7.2	49,063 ± 32,387 (2–137,473)
2018	171,976	31,007	21,130	31.8 ± 7	17,926 ± 12,513 (1–63,422)	227,562	78,268	52,994	32.4 ± 7	44,822 ± 29,926 (2–138,037)
2019	146,363	39,895	39,895	32.8 ± 7.4	22,606 ± 15,224 (1–72,134)	195,562	87,197	87,197	33.9 ± 7.4	50,957 ± 33,750 (1–140,693)
2020	94,157	20,965	14,219	32.9 ± 7.4	12,358 ± 8831 (2–46,161)	133,874	51,394	34,932	33.7 ± 7.3	29,294 ± 19,543 (2–90,686)
2021	108,641	42,799	28,961	33.5 ± 7.8	22,449 ± 13,553 (4–53,595)	137,464	73,750	29,056	32.8 ± 7	21,715 ± 12,600 (1–43,847)
2022	122,177	51,011	34,675	33.4 ± 7.7	27,175 ± 16,814 (2–67,891)	154,815	89,792	61,055	34.5 ± 7.7	48,484 ± 30,324 (3–117,302)

2.3. Workout Descriptions

Changes to the competition format have occurred throughout the CFO's history [3]. The competition has always released 1–2 workouts each week on Thursday evenings via live online broadcast, and competitors have always been allotted four days to complete the workout at their normal training facility and upload their best score to the online leaderboard [19]. With a few exceptions, competitors have always been given different instructions for completing Rx (i.e., 'as prescribed') and scaled versions of each workout, as well as those prescribed to teen and masters athletes [2,3]. Additional workout versions were programmed in more recent years with the introduction of the adaptive, foundations, and equipment-free divisions. In each instance, the modified workout typically programmed variants of Rx exercises, prescribed different repetition counts (per exercise), and/or different intensity loads when applicable [3]. Because these differences alter the assigned workload, equating different CrossFit®-style workouts is inherently difficult [21], and verifying modified workloads may not be possible, only Rx performances were considered for this study. Cases were also excluded if the reported age was not between 18 and 54 years due to the lack of clarity on the leaderboard about which workout version these athletes completed. Otherwise, all retained scores were assumed to have been representative of attempts made using Rx standards.

The data retained for analysis included the athlete's official rank for each workout and score, recorded as TTC (in minutes), repetitions, or load (in lbs. (kg)). Whenever the score could be officially quantified in multiple units (e.g., CFO 17.1 could be quantified as TTC or repetitions if the workout was not completed within the time limit), all scores were converted into a repetition completion rate (i.e., repetitions completed divided by TTC or workout duration; repetitions · $minute^{-1}$) as previously described [21,22]. In these instances, the calculated repetition completion rate was used for all statistical analyses and to present sex differences, whereas the original scoring format was used to present normative scores.

2.4. Statistical Analysis

Statistical software (SPSS, v.28.0, SPSS Inc., Chicago, IL, USA) was used for random sampling, as well as to calculate means, SDs, and percentiles for men and women separately.

Independent *t*-tests were used to examine sex differences for each workout. Significance was accepted at an alpha level of $p \leq 0.05$. Effect sizes (d) were also used to quantify the magnitude of any observed differences [23]. Interpretations of effect size were evaluated at the following thresholds: *trivial* ($d < 0.20$), *small* ($d = 0.20$), *medium* ($d = 0.50$), and *large* ($d \geq 0.80$). All data are reported as mean ± standard error (SE).

3. Results

The specific programming details for each workout included in this study are provided alongside their respective normative scores throughout Tables 2–7.

Sex Differences

In AMRAP-style workouts, significant ($p < 0.05$) differences between men and women in repetitions completed were observed in 33 (out of 35) workouts. Men outperformed women in 24 of these workouts with 1 by a *large* difference (CFO 19.1, $p < 0.001$, $d = 0.81$), 7 by *medium* differences ($p < 0.001$, $d = 0.52$–0.78), and 10 by *small* differences ($p < 0.001$, $d = 0.22$–0.48). Women completed more repetitions than men in nine workouts with four by *medium* differences ($p < 0.001$, $d = 0.51$–0.77) and two by *small* differences (CFO 16.2, $p < 0.001$, $d = 0.36$; CFO 12.2, $p < 0.001$, $d = 0.46$). Sex differences in all remaining AMRAP-style workouts were either *trivial* or not significant. Mean differences (± SE) between sexes in AMRAP-style workouts are illustrated in Figure 1.

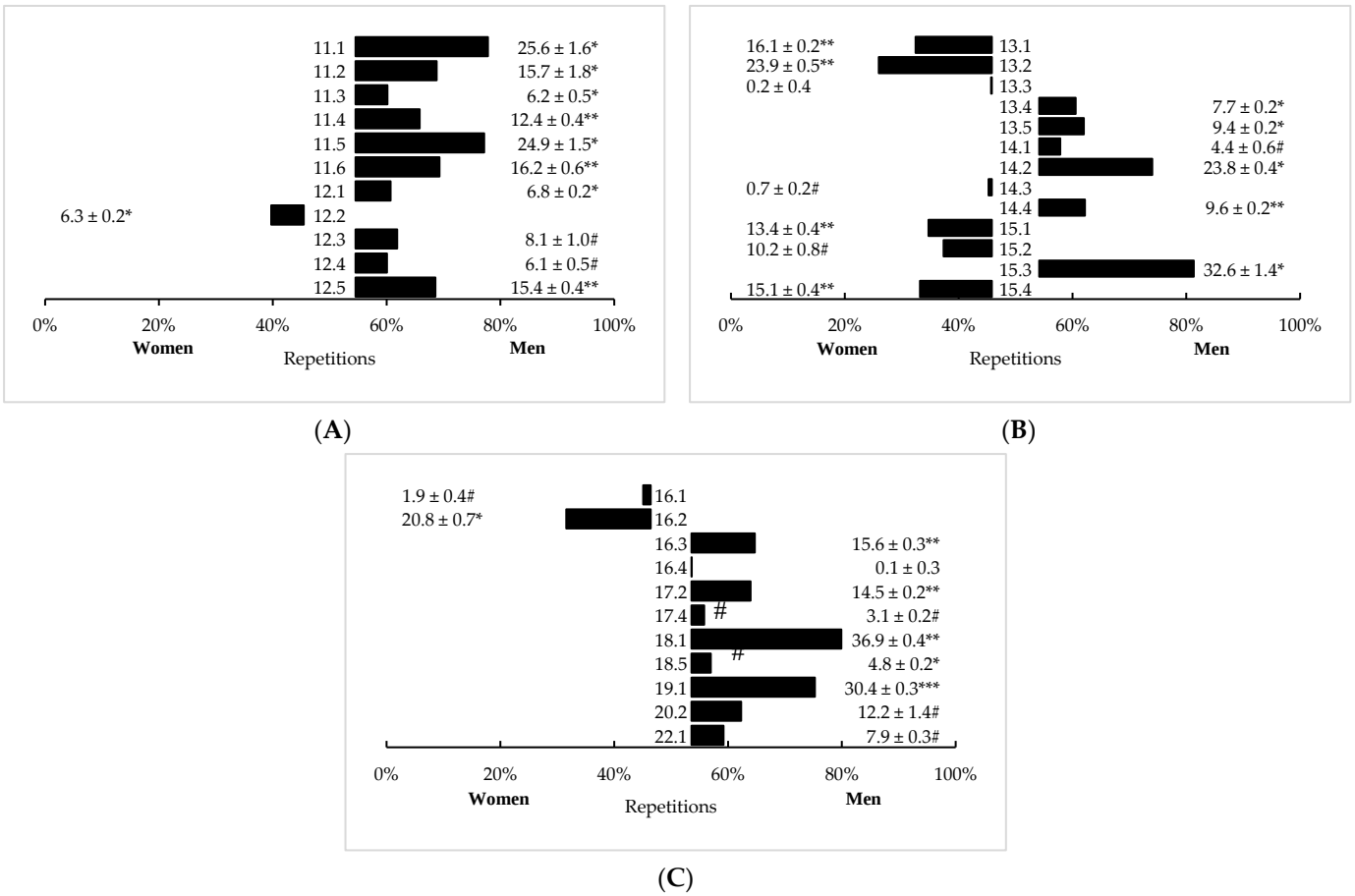


Figure 1. Sex differences in AMRAP-style CFO workouts programmed from (**A**) 2011–2012, (**B**) 2013–2015, and (**C**) 2016–2022 (mean difference ± SE). # = *Trivial*, significant ($p < 0.05$) difference between men and women. * = *Small*, significant ($p < 0.05$) difference between men and women. ** = *Medium*, significant ($p < 0.05$) difference between men and women. *** = *Large*, significant ($p < 0.05$) difference between men and women.

Table 2. Programming and normative scores for 2011–2012 CFO workouts.

Programming				Percentile Rank												
Workout	**Duration**	**Prescription**	**Sex**	**99**	**95**	**90**	**80**	**70**	**60**	**50**	**40**	**30**	**20**	**10**	**5**	**1**
11.1 repetitions	10 min AMRAP	30 × Double-unders 15 × Power snatches (75 lbs/55 lbs)	W M	355 389	315 352	304 333	270 308	261 293	244 269	224 259	214 240	196 220	175 195	148 165	131 135	94 95
11.2 repetitions	15 min AMRAP	9 × Deadlifts (155 lbs/100 lbs) 12 × Push-ups 15 × Box jumps (24″/20″)	W M	507 511	437 453	410 430	376 398	354 373	338 353	324 336	304 321	288 303	269 284	246 260	225 237	188 197
11.3 repetitions	5 min AMRAP	1 × Squat clean (165 lbs/110 lbs) 1 × Jerk (165 lbs/110 lbs)	W M	71 73	59 63	52 58	44 50	38 45	33 40	29 36	24 31	19 26	12 20	5 12	1 5	1 1
11.4 repetitions	10 min AMRAP	60 × Bar-facing burpees 30 × Overhead squats (120 lbs/90 lbs) 10 × Ring muscle-ups	W M	109 143	95 127	91 118	90 102	90 96	84 93	78 90	73 89	69 81	65 74	61 66	60 62	60 60
11.5 repetitions	20 min AMRAP	5 × Power cleans (145 lbs/100 lbs) 10 × Toes-to-bar 15 × Wall ball shots (20 lbs/14 lbs to 10′/9′ target)	W M	360 387	318 341	304 322	278 303	260 281	246 270	233 252	216 242	205 225	185 214	157 189	132 173	90 128
11.6 repetitions	7 min AMRAP	3 × Thrusters (100 lbs/65 lbs) 3 × Chest-to-bar pull-ups ** Add 3 repetitions after each set*	W M	126 137	110 125	103 117	94 107	86 101	81 96	76 90	71 85	61 79	55 72	41 64	29 54	12 32
12.1 repetitions	7 min AMRAP	Burpees	W M	124 134	115 124	110 119	105 113	101 108	97 104	93 101	90 96	86 92	82 87	76 80	72 75	64 66
12.2 repetitions	10 min AMRAP	30 × Snatches (75 lbs/45 lbs) 30 × Snatches (135 lbs/75 lbs) 30 × Snatches (165 lbs/100 lbs) Max repetitions × Snatches (210 lbs/120 lbs)	W M	92 85	87 76	80 72	71 66	65 62	61 60	60 60	60 57	60 50	59 42	45 32	34 30	30 30
12.3 repetitions	18 min AMRAP	15 × Box jumps (24″/20″) 12 × Push press (115 lbs/75 lbs) 9 × Toes-to-bar	W M	422 421	370 375	341 349	309 315	285 294	270 275	251 260	238 243	223 231	204 211	178 193	160 168	105 129
12.4 repetitions	12 min AMRAP	150 × Wall ball shots (20 lbs/14 lbs to 10′/9′ target) 90 × Double-unders 30 × Muscle-ups	W M	255 265	247 257	243 253	240 248	240 245	240 242	240 240	225 240	202 213	182 187	164 166	155 156	150 150
12.5 repetitions	7 min AMRAP	3 × Thrusters (100 lbs/65 lbs) 3 × Chest-to-bar pull-ups ** Add 3 repetitions after each set*	W M	126 137	111 123	104 115	91 104	85 99	80 93	75 87	68 82	58 76	52 70	34 61	28 54	13 31

* = Special instructions applied to specific workout's prescription.

Table 3. Programming and normative scores for 2013–2014 CFO workouts.

Programming				Percentile Rank												
Workout	**Duration**	**Prescription**	**Sex**	**99**	**95**	**90**	**80**	**70**	**60**	**50**	**40**	**30**	**20**	**10**	**5**	**1**
13.1 repetitions	17 min AMRAP	*Alternate the following exercises:* 40 → 30 → 20 → 10 × Burpees 30 × Snatches at (75 lbs/45 lbs) → (135 lbs/75 lbs) → (165 lbs/100 lbs) Then, max repetitions × Snatches (210 lbs/120 lbs)	W	191	176	168	159	153	150	150	150	146	131	118	108	100
			M	174	163	158	151	150	141	128	122	115	108	101	100	100
13.2 repetitions	10 min AMRAP	5 × Shoulder-to-overheads (115 lbs/75 lbs) 10 × Deadlifts (115 lbs/75 lbs) 15 × Box jumps (24″/20″)	W	350	325	310	295	280	270	260	249	240	228	210	197	170
			M	330	303	288	270	256	243	235	225.8	213	204	186	177	153
13.3 repetitions	12 min AMRAP	150 × Wall ball shots (20 lbs/14 lbs to 10′/9′ target) 90 × Double-unders 30 × Muscle-ups	W	257	249	245	240	240	240	240	240	215	193	170	158	150
			M	266	258	254	248	244	241	240	235	206	183	164	155	150
13.4 repetitions	7 min AMRAP	3 × Clean and jerk (135 lbs/95 lbs) 3 × Toes-to-bar ** Add 3 repetitions after each set*	W	103	94	88	76	71	68	64	61	56	47	42	37	21
			M	108	100	95	87	79	73	70	67	63	60	48	43	35
13.5 repetitions	≥4 min AMRAP	15 × Thrusters (100 lbs/65 lbs) 15 × Chest-to-bar pull-ups ** Add 4 min each time 3 sets are completed within time limit*	W	144	84	78	70	61	57	54	51	49	46	42	38	30
			M	152	130	87	78	72	68	64	60	55	51	46	42	35
14.1 repetitions	10 min AMRAP	30 × Double-unders 15 × Power snatches (75 lbs/55 lbs)	W	371	341	311	297	267	258	235	220	210	179	150	129	90
			M	381	348	316	303	273	262	249	224	211	179	142	121	90
14.2 repetitions	3 min rounds (indefinite)	*Complete 2 sets of:* 10 × Overhead squats (95 lbs/65 lbs) 10 × Chest-to-bar pull-ups ** Add 3 min and 2 repetitions after each set*	W	203	143	134	114	82	77	68	59	36	33	29	24	20
			M	254	194	175	133	122	109	82	76	69	59	34	27	20
14.3 repetitions	8 min AMRAP	*Alternate the following exercises:* Deadlifts: 10 × (135 lbs/95 lbs) → 15 × (185 lbs/135 lbs) → 20 × (225 lbs/155 lbs) → 25 × (275 lbs/185 lbs) → 30 × (315 lbs/205 lbs) → 35 × (365 lbs/225 lbs) 15 × Box jumps (24″/20″)	W	158	147	141	135	130	119	110	106	102	97	91	90	62
			M	152	143	138	132	130	117	110	106	102	98	93	90	69
14.4 repetitions	14 min AMRAP	60-calorie Rowing 50 × Toes-to-bar 40 × Wall ball shots (20 lbs/14 lbs to 10′/9′ target) 30 × Cleans (135 lbs/95 lbs) 20 × Ring muscle-ups	W	191	184	181	180	180	176	170	164	159	153	141	124	93
			M	213	194	190	185	182	180	180	177	171	164	156	146	102
14.5 TTC	No time limit	*21 → 18 → 15 → 12 → 9 → 6 → 3 repetitions:* Thrusters (95 lbs/65 lbs) Burpees	W	10:39	11:01	12:51	14:01	15:01	16:01	16:01	17:01	19:01	20:01	22:01	25:21	30:01
			M	10:40	12:01	13:01	14:33	15:01	16:01	17:01	19:01	20:01	22:21	25:01	27:01	34:01

* = Special instructions applied to specific workout's prescription.

Table 4. Programming and normative scores for 2015–2016 CFO workouts.

	Programming			Percentile Rank												
Workout	**Duration**	**Prescription**	**Sex**	**99**	**95**	**90**	**80**	**70**	**60**	**50**	**40**	**30**	**20**	**10**	**5**	**1**
15.1 repetitions	9 min AMRAP	15 × Toes-to-bar 10 × Deadlifts (115 lbs/75 lbs) 5 × Snatches (115 lbs/75 lbs)	W M	218 211	205 190	191 182	182 166	175 158	162 152	158 147	154 136	149 129	136 124	127 117	120 103	98 90
15.1 a lbs. (kg)	6 min time limit	*Immediately into:* 1-RM Clean and jerk	W M	220 (99.8) 316 (143.5)	202 (91.6) 290 (131.5)	193 (87.5) 275 (124.7)	181 (82.1) 255 (115.7)	175 (79.4) 245 (111.1)	165 (74.8) 235 (106.6)	160 (72.6) 225 (102.1)	155 (70.3) 215 (97.5)	145 (65.8) 205 (93)	140 (63.5) 198 (89.8)	134 (60.8) 185 (83.9)	125 (56.7) 176 (79.8)	115 (52.2) 165 (74.8)
15.2 repetitions	3 min rounds (indefinite)	*Complete 2 sets:* 10 × Overhead squats (95 lbs/65 lbs) 10 × Chest-to-bar pull-ups ** Add 3 min and 2 repetitions after each set*	W M	278 277	254 244	202 199	192 179	172 140	138 134	133 127	128 118	117 109	86 83	80 74	75 67	63 56
15.3 repetitions	14 min AMRAP	7 × Ring muscle-ups 50 × Wall ball shots (20 lbs/14 lbs to 10′/9′ target) 100 × Double-unders	W M	478 504	447 474	371 436	332 362	318 340	315 320	279 316	211 301	171 236	161 190	158 160	157 158	157 157
15.4 repetitions	8 min AMRAP	3 × Handstand push-ups 3 × Cleans (185 lbs/125 lbs) ** Add 3 repetitions after each set*	W M	143 128	124 106	111 95	98 80	89 71	80 64	73 56	66 51	57 45	50 36	37 28	30 20	16 10
15.5 TTC	No time limit	*27 → 21 → 15 → 9 repetitions:* Rowing (calories) Thrusters (95 lbs/65 lbs)	W M	7:18 6:29	7:59 7:25	8:28 7:59	9:40 8:51	9:38 9:31	10:56 10:06	10:36 10:44	11:50 11:24	11:40 12:10	12:28 13:06	13:39 14:33	14:46 15:54	17:27 19:40
16.1 repetitions	20 min AMRAP	25 ft Overhead walking lunge (95 lbs/65 lbs) 8 × Burpees 25 ft Overhead walking lunge (95 lbs/65 lbs) 8 × Chest-to-bar pull-ups	W M	289 291	260 260	239 240	219 219	206 206	194 193	183 182	174 171	166 163	156 153	143 136	130 124	108 104
16.2 repetitions	4 min rounds (20 min time limit)	25 × Toes-to-bar 50 × Double-unders Squat cleans: 15 × (135 lbs/85 lbs) → 13 × (185 lbs/115 lbs) → 11 × (225 lbs/145 lbs) → 9 × (275 lbs/175 lbs) 7 × (315 lbs/205 lbs) ** Add 4 min for each completed set*	W M	425 346	343 339	339 260	259 255	255 234	253 175	176 172	173 170	171 168	168 166	165 165	154 144	119 114
16.3 repetitions	7 min AMRAP	10 × Power snatches (75 lbs/55 lbs) 3 × Bar muscle-ups	W M	117 123	103 111	95 103	86 96	76 89	70 86	63 78	53 75	49 69	37 62	25 49	24 37	23 23
16.4 repetitions	13 min AMRAP	55 × Deadlifts (225 lbs/155 lbs) 55 × Wall ball shots (20 lbs/14 lbs to 10′/9′) 55-calorie Rowing 55 × Handstand push-ups	W M	257 256	229 225	211 209	199 197	191 190	185 185	181 181	177 177	172 173	167 169	159 165	146 149	114 111
16.5 TTC	No time limit	*21 → 18 → 15 → 12 → 9 → 6 → 3 repetitions:* Thrusters (95 lbs/65 lbs) Burpees	W M	9:16 9:27	10:22 10:48	11:06 11:42	12:30 12:51	12:49 13:45	13:30 14:35	14:09 15:22	14:47 16:14	15:34 17:10	16:34 18:23	18:30 20:20	19:17 21:47	22:20 25:21

* = Special instructions applied to specific workout's prescription.

Table 5. Programming and normative scores for 2017–2018 CFO workouts.

		Programming		Percentile Rank												
Workout	**Duration**	**Prescription**	**Sex**	**99**	**95**	**90**	**80**	**70**	**60**	**50**	**40**	**30**	**20**	**10**	**5**	**1**
17.1 TTC → repetitions	20 min time limit	*Alternate the following:* Dumbbell snatches (50 lbs/35 lbs): × 10 → 20 → 30 → 40 → 50 repetitions 15 × Burpee box jump-overs (24″/20″)	W	12:15	13:54	14:59	16:23	17:25	18:22	19:11	19:53	215	203	183	170	149
			M	12:50	13:51	14:58	16:30	17:39	18:38	19:29	220	211	195	177	164	145
17.2 repetitions	12 min AMRAP	*Complete 2 sets:* 50 ft Walking dumbbell lunges (50 lbs/35 lbs) 16 × Toes-to-bar 8 × Dumbbell power cleans (50 lbs/35 lbs) *Then, complete 2 sets:* 50 ft Walking dumbbell lunges (50 lbs/35 lbs) 16 × Bar muscle-ups 8 × Dumbbell power cleans (50 lbs/35 lbs)	W	182	141	122	113	91	85	80	78	78	78	78	78	73
			M	194	163	146	125	118	114	106	90	85	80	78	78	76
17.3 TTC → repetitions	8 min AMRAP (24 min time limit)	*Prior to 8 min, complete 3 sets:* 6 × Chest-to-bar pull-ups 6 × Squat snatches (95 lbs/65 lbs) *Then, complete 3 sets:* 7 × Chest-to-bar pull-ups 5 × Squat snatches (135 lbs/95 lbs) * *Add 4 min after completing 3 sets:* 8 → 9 → 10 → 11 × Chest-to-bar pull-ups Squat snatches: 4 × (185 lbs/135 lbs) → 3 × (225 lbs/155 lbs) → 2 × (245 lbs/175 lbs) → 1 × (265 lbs/185 lbs)	W	154	105	92	80	68	59	55	47	44	43	43	41	36
			M	167	119	105	92	80	71	65	57	52	45	43	43	38
17.4 repetitions	13 min AMRAP	55 × Deadlifts (225 lbs/155 lbs) 55 × Wall ball shots (20 lbs/14 lbs to 10′/9′ target) 55-calorie Rowing 55 × Handstand push-ups	W	256	218	203	190	183	177	173	169	165	165	149	134	98
			M	260	226	208	195	187	181	177	173	168	165	149	131	95
17.5 TTC → repetitions	40 min time limit	Complete 10 sets of: 9 × Thrusters (95 lbs/65 lbs) 35 × Double-unders	W	8:06	9:33	10:34	12:50	13:20	14:31	15:46	17:10	18:53	21:30	26:25	32:24	323
			M	8:20	9:40	10:48	12:31	13:58	15:25	16:56	18:38	20:46	24:40	30:33	38:47	265
18.1 repetitions	20 min AMRAP	8 × Toes-to-bar 10 × Dumbbell hang clean and jerks (50 lbs/35 lbs) 14-calorie Rowing	W	379	348	329	307	291	278	268	257	245	232	215	200	175
			M	425	391	370	347	330	320	305	292	279	264	245	232	203
18.2 TTC → repetitions	12 min time limit	*Complete 1 → 2 → 3 → 4 → 5 → 6 → 7 → 8 → 9 → 10 repetitions:* Dumbbell squats (50 lbs/35 lbs) Bar-facing burpees	W	4:46	5:31	5:58	6:34	6:58	7:22	7:43	8:50	8:31	9:00	9:47	10:21	11:15
			M	4:35	5:22	5:49	6:25	6:53	7:18	7:43	8:08	8:36	9:10	9:56	10:32	11:25
18.2 a lbs. (kg)		*Then:* 1-RM Clean	W	225 (102.1)	205 (93)	192 (87.1)	178 (80.7)	170 (77.1)	161 (73)	155 (70.3)	147 (66.7)	142 (64.4)	135 (61.2)	125 (56.7)	115 (52.2)	100 (45.4)
			M	335 (152)	305 (138.3)	287 (130.2)	267 (121.1)	255 (115.7)	243 (110.2)	232 (105.2)	225 (102.1)	212 (96.2)	200 (90.7)	185 (83.9)	175 (79.4)	154 (69.9)

Table 5. *Cont.*

Programming				Percentile Rank												
Workout	**Duration**	**Prescription**	**Sex**	**99**	**95**	**90**	**80**	**70**	**60**	**50**	**40**	**30**	**20**	**10**	**5**	**1**
18.3 TTC → repetitions	14 min time limit	*Complete 2 sets:* 100 × Double-unders 20 × Overhead squats (115 lbs/80 lbs) 100 × Double-unders 12 × Ring muscle-ups 100 × Double-unders 20 × Dumbbell snatches (50 lbs/35 lbs) 100 × Double-unders 12 × Bar muscle-ups	W M	689 722	578 675	486 584	432 536	230 462	224 453	220 380	220 302	220 227	220 222	220 220	220 220	162 152
18.4 TTC → repetitions	9 min time limit	*Complete 21-15-9 repetitions:* Deadlifts (225 lbs/155 lbs) Handstand push-ups *Then, complete 21-15-9 repetitions:* Deadlifts (315 lbs/205 lbs) Handstand walk (50′)	W M	164 155	136 131	119 118	111 109	103 101	96 96	89 90	83 85	70 72	65 66	60 61	58 59	48 50
18.5 repetitions	7 min AMRAP	3 × Thrusters (100 lbs/65 lbs) 3 × Chest-to-bar pull-ups **Add 3 repetitions after each set*	W M	160 157	137 137	123 126	111 114	104 106	97 101	90 96	85 90	81 86	77 81	67 74	56 69	33 60

* = Special instructions applied to specific workout's prescription.

Table 6. Programming and normative scores for 2019–2020 CFO workouts.

Programming				Percentile Rank												
Workout	**Duration**	**Prescription**	**Sex**	**99**	**95**	**90**	**80**	**70**	**60**	**50**	**40**	**30**	**20**	**10**	**5**	**1**
19.1 repetitions	15 min AMRAP	19 × Wall ball shots (20 lbs/14 lbs to 10′/9′ target) 19-calorie Rowing	W M	309 354	287 327	273 313	258 295	248 284	239 270	229 261	222 249	213 240	204 228	190 210	177 198	154 171
19.2 TTC → repetitions	4 min rounds (20 min time limit)	25 × Toes-to-bar 50 × Double-unders Squat cleans: 15 × (135 lbs/85 lbs) → 13 × (185 lbs/115 lbs) → 11 × (225 lbs/145 lbs) → 9 × (275 lbs/175 lbs) 7 × (315 lbs/205 lbs) ** Add 4 min for each set*	W M	424 345	339 263	259 258	253 253	175 174	171 171	167 168	165 166	137 156	111 115	101 101	93 90	82 81
19.3 TTC → repetitions	10 min time limit	200 ft Dumbbell overhead lunge (50 lbs/35 lbs) 50 × Dumbbell box step-ups (50 lbs/35 lbs onto 24″/20″ box) 50 × Strict handstand push-ups 200 ft Handstand walking	W M	159 161	134 140	120 129	107 118	98 111	93 105	90 100	90 96	90 92	90 90	90 86	87 72	59 52
19.4 TTC → repetitions	12 min time limit	*Complete 3 sets:* 10 × Snatches (95 lbs/65 lbs) 12 × Bar-facing burpees *Then, rest 3 min before completing 3 sets:* 10 × Bar muscle-ups 12 × Bar-facing burpees	W M	11:26 10:24	115 11:44	110 121	93 113	88 110	72 97	67 93	66 90	66 76	66 70	66 66	66 66	66 66

Table 6. *Cont.*

Programming				Percentile Rank												
Workout	**Duration**	**Prescription**	**Sex**	**99**	**95**	**90**	**80**	**70**	**60**	**50**	**40**	**30**	**20**	**10**	**5**	**1**
19.5 TTC → repetitions	20 min time limit	*Complete 33 → 27 → 21 → 15 → 9 repetitions:* Thrusters (95 lbs/65 lbs) Chest-to-bar pull-ups	W M	11:28 11:07	15:09 14:12	17:14 16:14	19:46 18:47	190 203	179 187	163 177	152 165	143 153	126 142	107 127	98 113	83 89
20.1 TTC → repetitions	15 min time limit	*Complete 10 sets:* 8 × Ground-to-overheads (95 lbs/65 lbs) 10 × Bar-facing burpees	W M	10:16 10:27	11:50 12:09	12:44 13:06	13:49 14:11	14:33 14:50	178 170	168 164	162 157	154 149	147 144	136 131	128 126	113 109
20.2 repetitions	20 min AMRAP	4 × Dumbbell thrusters (50 lbs/35 lbs) 6 × Toes-to-bar 24 × Double-unders	W M	851 855	740 751	684 691	616 636	577 586	538 549	510 515	476 481	442 446	393 408	340 341	280 281	194 198
20.3 TTC → repetitions	9 min time limit	*Complete 21-15-9 repetitions:* Deadlifts (225 lbs/155 lbs) Handstand push-ups *Then, complete 21-15-9 repetitions:* Deadlifts (315 lbs/205 lbs) Handstand walk (50′)	W M	8:39 163	139 134	124 122	112 111	105 103	97 97	90 92	84 87	70 80	65 67	60 61	57 58	47 50
20.4 TTC → repetitions	20 min time limit	*Alternate the following:* 30 × Box jumps (24″/20″) Clean and jerks: 15 × (95 lbs/65 lbs) → 15 × (135 lbs/85 lbs) → 10 × (185 lbs/115 lbs.) *Then, alternate the following:* 30 × Single-leg squats Clean and jerks: 10 × (225 lbs/145 lbs) → 5 × (275 lbs/175 lbs) → 5 × (315 lbs/205 lbs.)	W M	17:55 237	235 215	235 201	201 200	200 177	200 166	169 162	163 160	160 160	160 151	160 127	130 121	120 120
20.5 TTC → repetitions	20 min time limit	*Partition in any way:* 40 × Ring muscle-ups 80-calorie Rowing 120 × Wall ball shots (20 lbs/14 lbs to 10′/9′ target)	W M	15:16 12:27	19:50 14:09	230 16:06	217 18:11	209 237	178 170	168 164	162 157	154 149	147 144	136 131	128 126	113 109

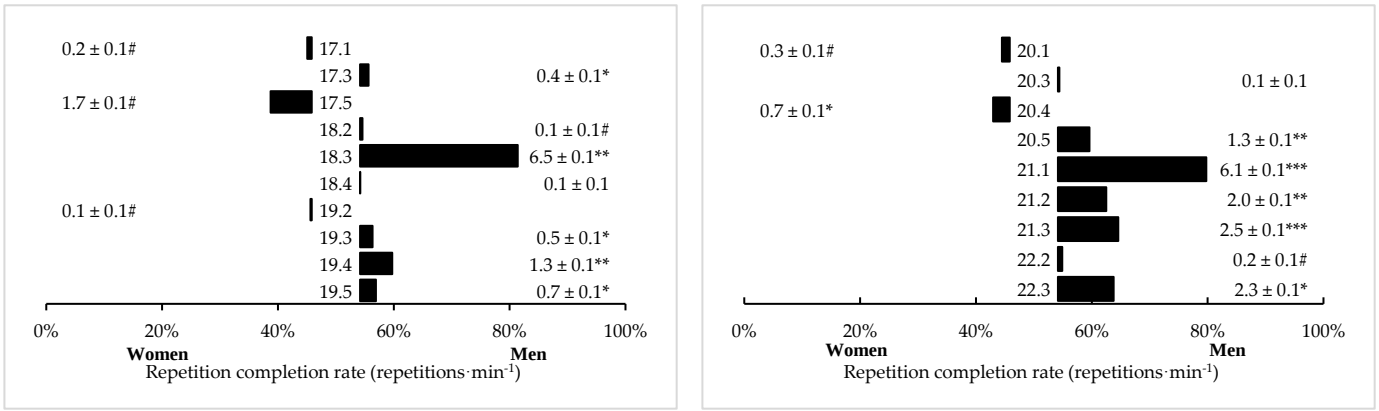
* = Special instructions applied to specific workout's prescription.

Table 7. Programming and normative scores for 2021–2022 CFO workouts.

Programming				Percentile Rank												
Workout	**Duration**	**Prescription**	**Sex**	**99**	**95**	**90**	**80**	**70**	**60**	**50**	**40**	**30**	**20**	**10**	**5**	**1**
21.1 TTC → repetitions	15 min time limit	*Alternate the following:* Wall walks × 1 → 3 → 6 → 9 → 15 → 21 repetitions Double-unders × 10 → 30 → 60 → 90 → 150 → 210 repetitions	W M	588 14:16	395 505	387 415	379 389	355 384	283 381	222 378	217 374	213 332	182 277	115 221	110 217	44 210
21.2 TTC → repetitions	20 min time limit	*Alternate the following:* Dumbbell snatches (50 lbs/35 lbs): × 10 → 20 → 30 → 40 → 50 repetitions 15 × Burpee box jump-overs (24″/20″)	W M	11:14 10:47	12:51 11:57	13:52 12:44	15:15 13:47	16:26 14:35	17:32 15:18	18:35 15:59	19:36 16:41	217 17:26	201 18:18	177 19:21	160 19:59	131 205
21.3 TTC → repetitions	15 min time limit	15 × Front squats (95 lbs/65 lbs) 30 × Toes-to-bar 15 × Thrusters (95 lbs/65 lbs) *Rest 1 min, then:* 15 × Front squats (95 lbs/65 lbs) 30 × Chest-to-bar pull-ups 15 × Thrusters (95 lbs/65 lbs) *Rest 1 min, then:* 15 × Front squats (95 lbs/65 lbs) 30 × Bar muscle-ups 15 × Thrusters (95 lbs/65 lbs)	W M	11:14 10:47	12:51 11:57	158 12:44	146 13:47	139 166	135 159	135 155	135 151	120 147	95 143	77 139	75 136	75 135
21.4 lbs (kg)	7 min time limit	*After 15 min time limit:* 1-RM Complex of Deadlift → Clean → Hang clean → Jerk	W M	197 (89.4) 292 (132.4)	176 (79.8) 267 (121.1)	165 (74.8) 255 (115.7)	154 (69.9) 238 (108)	145 (65.8) 227 (103)	135 (61.2) 220 (99.8)	130 (59) 211 (95.7)	125 (56.7) 205 (93)	117 (53.1) 198 (89.8)	110 (49.9) 187 (84.8)	101 (45.8) 177 (80.3)	95 (43.1) 167 (75.7)	85 (38.6) 154 (69.9)
22.1 repetitions	15 min AMRAP	3 × Wall walks 12 × Dumbbell snatches (50 lbs/35 lbs) 15 × Box jump-overs (24″/20″)	W M	317 316	283 289	270 272	242 248	228 240	212 219	202 211	184 196	179 182	154 167	138 150	121 125	80 92
22.2 TTC → repetitions	10 min time limit	*1 → 2 → 3 → 4 → 5 → 6 → 7 → 8 → 9 → 10 → 9 → 8 → 7 → 6 → 5 → 4 → 3 → 2 → 1 repetitions of:* Deadlifts (225 lbs/155 lbs) Bar-facing burpees	W M	9:10 9:36	180 183	169 171	157 158	147 149	139 141	132 133	125 126	117 117	110 111	95 96	83 89	57 62
22.3 TTC → repetitions	12 min time limit	21 × Pull-ups 42 × Double-unders 21 × Thrusters (95 lbs/65 lbs) 18 × Chest-to-bar pull-ups 36 × Double-unders 18 × Thrusters (115 lbs/75 lbs) 15 × Bar muscle-ups 30 × Double-unders 15 × Thrusters (135 lbs/85 lbs)	W M	6:10 6:36	9:34 8:23	11.2 9:39	169 11.55	161 208	156 183	156 165	156 160	154 156	132 156	89 142	84 113	84 86

In TTC-style workouts that did not have a time limit, *small* sex differences were noted where women completed CFO 14.5 (mean difference = 1.1 ± 0.1 min, $p < 0.001$, $d = 0.23$) and CFO 16.5 (mean difference = 1.3 ± 0.1 min, $p < 0.001$, $d = 0.40$) faster than men. A significant but trivial difference ($p < 0.001$, $d = 0.08$) was seen between women (10.9 ± 0.1 min) and men (11.1 ± 0.1 min) for CFO 15.5.

In time-limited TTC-style workouts, significant ($p < 0.05$) differences between men and women in repetition completion rate were observed in 17 (out of 19) workouts. Men completed 12 of these workouts at a faster rate than women, with 2 by *large* differences (CFO 21.1, $p < 0.001$, $d = 0.92$; CFO 21.3, $p < 0.001$, $d = 1.12$), 4 by *medium* differences ($p < 0.001$, $d = 0.61$–0.76), and 4 by *small* differences ($p < 0.001$, $d = 0.23$–0.46). Women completed CFO 20.4 at a faster rate than men, but by a *small* difference ($p < 0.001$, $d = 0.46$). Sex differences in all remaining time-limited TTC-style workouts were either *trivial* or not significant. Mean differences (±SE) between sexes in time-limited TTC-style workouts are illustrated in Figure 2.



(**A**) (**B**)

Figure 2. Sex differences in timed TTC-style CFO workouts programmed from (**A**) 2017–2019 and (**B**) 2020–2022 (mean difference ± SE). # = *Trivial*, significant ($p < 0.05$) difference between men and women. * = *Small*, significant ($p < 0.05$) difference between men and women. ** = *Medium*, significant ($p < 0.05$) difference between men and women. *** = *Large*, significant ($p < 0.05$) difference between men and women.

In workouts scored by load lifted, *large* sex differences ($p < 0.001$, $d = 2.00$–2.98) where men lifted more weight than women were seen for CFO 15.1a (mean difference = 13.7 ± 0.1 kg), CFO 18.2a (mean difference = 35.4 ± 0.1 kg), and CFO 21.4 (mean difference = 37.3 ± 0.1 kg). Body mass and height were not reported by all participants each year, and due to concerns about the accuracy and timeliness of available information, strength performance differences were not assessed relative to body size.

4. Discussion

The purpose of this study was to create normative scores for workouts programmed for the men's and women's divisions for the 2011 through 2022 CFO competitions. Objectively tracking progress with CrossFit® training is difficult because workouts vary daily to simultaneously stimulate adaptations in all relevant parameters of fitness [4]. Although any targeted physiological trait can be assessed by a variety of commonly accepted field and laboratory tests [13], the relevance of specific tests appears to vary [5–12] and evidence is not clear on which assessments are most insightful. It may also be impractical for non-researchers to acquire the more expensive, research-grade equipment needed to run traditional physiological assessments (e.g., metabolic cart, cycle ergometer, force plates). Instead, it may be easier to use standardized CrossFit® workouts to monitor improvements. The annual CrossFit Games™ competition sets out to find the fittest men and women

through a series of stages, beginning with the CFO, and each stage features a unique battery of CrossFit®-style workouts [1–3]. Like the training style, each workout is designed to differentially challenge some combination of each athlete's strength, endurance, and sport-specific skill [2,4]. After their introduction, CFO workouts become benchmarks that may be incorporated into training. Unlike everyday workouts, the standard requirements of each benchmark workout allow trainees to relate changes in their score to improvements in either the physiological traits or skills associated with the specific workout. Additionally, because CFO competitors are ranked by their performance in each workout [3], trainees might use their improvements in benchmark workouts to gauge how they might place in future CFO competitions.

Although workout performances are ranked in the CFO [3], several inherent flaws in the ranking process could lead to misinterpretation of where one truly ranks and in the degree of improvement needed to advance in rank. Within a specific CFO competition, athletes who complete a workout 'as prescribed' (i.e., Rx) are ranked, albeit higher, on the same scale as athletes who completed a scaled version [3]. That is, completing only a single repetition of the Rx workout will earn a higher rank than a record-setting performance in a scaled version of the same workout. Because this can improve their rank by several thousand places, athletes may attempt the Rx version knowing that they do not possess the skill or capacity to complete the entire workout or some of its components. Regardless, the inclusion of these well-below-average performances skews the calculation of a score's associated percentile rank. Percentile ranks may also be skewed by the inclusion of "specialist" performances by athletes who only complete or submit scores for workouts that suit their strengths. While their performance in the specific workout that suited their skills may not be objectionable in itself, their extremely poor or non-existent performances in all other workouts make it difficult to affirm that they are part of the main competition's population (i.e., athletes who capably completed all workouts within a single competition). Rather, because they could (or did) not complete all workouts, these athletes should be more closely associated with the scaled division populations. Likewise, athletes who intentionally (or unintentionally) fail to meet movement standards, miscount repetitions, or outright cheat, and still manage to successfully validate their score, cannot be viewed as being part of the main competition population. The presence of these scores adds too much variability to produce precise ranking thresholds from the entire pool of scores. Consequently, this study used very specific and standardized criteria to limit their inclusion before calculating any normative scores.

Rank-boosting performances skew the final population of scores [20] and lead to reduced thresholds distinguishing performance among higher percentile ranks. Previously, normative values were established from the self-reported scores for the five benchmark workouts that CFO competitors may upload to their user profiles [17]. In that study, exaggerated scores were addressed by uniform removal of all cases exceeding four SDs from the mean. This was problematic because SD is calculated from all scores [20] and uniformly removing scores based on its position on the normal curve will necessarily lead to illegitimate attempts causing a portion of valid attempts to be removed from both tails. Therefore, the present study used a different approach and only removed cases when the reported score did not exceed the minimum expectation for a legitimate attempt. This process still produced limitations because the minimum expectations were subjective creations and varied in degree of stringency depending on each workout's programming. For instance, completing "one round" in AMRAP-style workouts resulted in the minimum expectation being as few as two repetitions (e.g., CFO 11.3 and CFO 12.1) to as many as 157 repetitions (i.e., CFO 15.3). When the threshold required athletes to complete the first exercise or exercise couplet, no greater ambiguity existed than when deciding what this criterion meant for CFO 20.5. In that workout, athletes could partition the workload (120 wall ball shots, 80 calories of rowing, and 40 ring muscle-ups) any way. Fortunately, pilot work suggested that within the top 10,000 competitors, legitimate attempts accumulated at least 80 repetitions between the rowing and wall ball shots but not

necessarily both, and 40 muscle-ups would be the performance distinguishing factor [24]. These criteria still do not prevent legitimate attempts from being removed, and greater reliance is placed on the authors' familiarity with the sport. Nevertheless, these criteria were consistently applied across all workouts and eliminated the arbitrary removal of elite performances, and it seems reasonable to assume that the resultant normative scores would still accurately place any valid, low-ranking (i.e., <1%) performances that were removed by this process.

Cases involving "specialists", systematic reporting errors, and outright cheating also skew performances and lead to inflated thresholds distinguishing higher percentile ranks [20]. Like the previous normative study [17], these were dealt with by random athlete selection of the remaining cases [20]. This process does not guarantee the elimination of these cases but helps to reduce any systematic appearances to produce normative scores that are not artificially pulled in either direction. Although the success of these criteria can only be verified by a costly, international-scale, in-person study to repeat 11 years of CFO workouts, this does not seem to be necessary. The study criteria were designed to produce percentile scores that were relevant to and in line with the definition of the overall CrossFit® ideology [4].

A secondary aim of this study was to compare performances by men and women across each CFO workout. The sport emphasizes gender equity in the number of male and female competitors invited to compete at the CrossFit Games™, the monetary compensation [25], and the design of each workout [2,3]. Regarding the latter, CFO workouts are often scaled between sexes, presumably to elicit a similar challenge and account for known physiological differences. Theoretically, appropriate scaling should yield no differences between men and women in repetitions completed or TTC. CFO programming accomplished this by adjusting prescribed weight training exercise loads for women to be approximately 66.9 ± 4.4% of the weight assigned to men, or uniformly reducing women's box height (for jumps, jump-overs, or step-ups) by ~17%, medicine ball weight by 30%, and wall ball shot target height by 10% from their respective prescriptions in men [2]. Such adjustments were present for at least one exercise in 55 (out of 60) CFO workouts. Still, sex differences were observed in 51 (of the 55 scaled workouts) and in all unscaled workouts (i.e., sex differences were noted in a total of 56 workouts).

Men are generally stronger than women [26]. Indeed, the *largest* performance differences were noted in the three workouts that required athletes to find their 1-RM (CFO 15.1a, CFO 18.2a, and CFO 21.4). CFO workouts presumably attempt to account for expected strength differences by adjusting weight training exercise loads (50 out of 60 workouts) and box height and wall ball shot criteria (18 out of 60 workouts). Even when the workout contained no purposefully scaled component, it may be argued that the design naturally accounted for strength differences. Body mass, which typically differs between men and women [26,27], altered the intensity of the only "unscaled" workouts that did not program 1-RMs (i.e., CFO 12.1 and CFO 21.1). Nevertheless, persistent differences in performance suggest that scaling was not sufficient to equate the challenge for most athletes. Without counting 1-RM workouts, ties were only noted in 7% (n = 4) of CFO workouts. Otherwise, men or women outperformed the other sex ~63% (n = 36) or ~30% (n = 17) of the time, respectively. Interestingly, average relative loads assigned to women varied from the average prescribed across all CFO workouts whenever either sex performed better. When men scored better than women, the loads assigned to women were slightly higher (68.3 ± 2.7% of loads assigned to men), and then slightly less (64.7 ± 4.0% of loads assigned to men) when women scored better than men. When men and women tied and the workouts involved a resistance training exercise (i.e., CFO 16.4, CFO 18.4, and CFO 20.3), relative loads prescribed to women (67.4 ± 2.1% of loads assigned to men) was closer to the average. However, the workouts only needed to adjust loads for one exercise, the deadlift. Thus, it may be hypothesized that the absolute loads assigned to men and women played a role in the observed performance differences and that ideal load scaling may vary based on the specific exercise.

Another programming aspect to consider is the lack of scaling for either the number of repetitions assigned to gymnastic–calisthenic exercises or the duration of traditional aerobic modalities. Besides the 1-RM workouts, men outperformed women by *large* differences in CFO 19.1, CFO 21.1, and CFO 21.3. While CFO 19.1 scaled wall ball shots and CFO 21.3 scaled front squat and thruster loads, all three workouts were 15 min long and involved unscaled, high-volume prescription for exercises that required upper-body muscular endurance (e.g., rowing, wall walks, muscle-ups, etc.). Likewise, in 7 of the 11 workouts where men scored better than women by a *medium* difference, the workout duration was between 10 and 20 min and included at least one high-volume, upper-body gymnastic exercise. Men are also known to possess greater aerobic and anaerobic capacity and more upper-body strength endurance than women [27–29], and not scaling these components may have contributed to them performing better. That said, there were two instances (CFO 15.1 and CFO 15.4) where unscaled, upper-body gymnastic exercises were programmed, and women outperformed men. However, both workouts also programmed 1–2 scaled, resistance training exercises that could have helped to offset any disadvantage they may have had from the toes-to-bar or handstand push-up exercises.

Men will typically outperform women whenever absolute values for traditional measures of strength and endurance are used, but not when these measures are standardized (e.g., percentage of 1-RM, per kilogram of body mass) [29–31]. Though it is beyond the scope of this study to speculate on the feasibility of relative programming or scaling gymnastic and aerobic components, these findings suggest CFO programming is regularly providing a different challenge to men and women. A counter argument is that it may be unnecessary, excessively tedious, and nearly impossible to equate CFO workout difficulty between sexes on an annual basis. Men and women do not directly compete, and a better performance from either sex will not impact their rankings [3]. Complicating prescription by assigning relative loads (e.g., percentages of established 1-RM) might create additional opportunities for cheating, and this would still not address traditionally unscaled components. It may also only be a matter of time before existing scaling methods naturally become regularly sufficient. Further analyses of data previously presented by Mangine [16] showed that women have experienced an ~8.3% improvement across all repeated CFO workouts compared with ~2.8% in similarly ranked men. Additionally, representation by women in the CFO has grown from 34.3% to 44.1% of all competitors in 2011 and 2022, respectively [19], and from 30.2% to 36.2% of all competitors meeting this study's criteria. The combination of improved fitness and greater participation may naturally eliminate any regularity seen between sexes in CFO performance. Meanwhile, the purpose of the CFO is to identify the athletes who will be able to be competitive at later rounds (i.e., currently the top 10%) [3]. Manipulating prescription to equate the challenge when differences were predominantly (39 of 60 CFO workouts) *small*, *trivial*, or non-existent might be irrelevant to that purpose.

5. Conclusions

The present study created normative values for men and women in all CFO workouts. These data provide a current representation of the standards that distinguish performance in an ever-growing list of benchmark workouts. Periodic updates to account for changes in the population and new CFO workouts will undoubtedly be needed in the future. However, it is foreseeable that the list, currently at 60, will easily surpass 100 in the next decade and beyond, especially if traditional benchmark and "Hero" workouts are also considered. Such efforts may ultimately prove to be redundant and unnecessary. Recently, it was suggested that relationships might exist amongst workouts and/or workout components (e.g., the pull-up component of "Fran") [21]. If true, workout components or entire workouts might be classified, and normative scores may only be necessary for symbolic representations of workout types or classifications. Currently, however, fair associations are impossible without the development of a simple and universal method for quantifying and equating workloads in any CrossFit®-style workout.

For the time being, the normative scores calculated in this study may be useful to CrossFit® trainees and athletes for identifying strengths and weaknesses, assessing progress, and establishing realistic training goals. As research on this training strategy continues to grow, these values may help researchers to better identify individuals who are most representative of a targeted population. Existing studies have typically relied on the presence (or lack of) training experience (i.e., years of participation) to define a participant's familiarity with CrossFit® or high-intensity functional training. However, proficiency with the massive array of exercises that could potentially appear during a workout, as well as capability in regularly selecting appropriate pacing strategies, cannot be inferred simply from years of experience. In contrast, each year's battery of CFO workouts was meant to, albeit variably, challenge aptitude across a broad range of sport-related traits and skills [2,3]. Not only are the selected exercises, movement standards, and prescriptions commonly incorporated into training, but standardized equipment makes it easier for most training facilities and laboratories to be adequately equipped for these workouts. Moreover, because CFO workouts are all designed to produce a score that distinguishes performance, these normative values can readily quantify individual skill in a single CFO workout or battery of workouts. Athletes, coaches, and researchers need only select the workouts that most closely resemble the needs of their training or study.

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