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COVID-19 Lockdown: A Global Study Investigating the Effect of Athletes' Sport Classification and Sex on Training Practices

Jad Adrian Washif, Øyvind Sandbakk, Stephen Seiler, Thomas Haugen, Abdulaziz Farooq, Ken Quarrie, Dina C. Janse van Rensburg, Isabel Krug, Evert Verhagen, Del P. Wong, Iñigo Mujika, Cristina Cortis, Monoem Haddad, Omid Ahmadian, Mahmood Al Jufaili, Ramzi A. Al-Horani, Abdulla Saeed Al-Mohannadi, Asma Aloui, Achraf Ammar, Fitim Arifi, Abdul Rashid Aziz, Mikhail Batuev, Christopher Martyn Beaven, Ralph Beneke, Arben Bici, Pallawi Bishnoi, Lone Bogwasi, Daniel Bok, Omar Boukhris, Daniel Boullosa, Nicola Bragazzi, Joao Brito, Roxana Paola Palacios Cartagena, Anis Chaouachi, Stephen S. Cheung, Hamdi Chtourou, Germina Cosma, Tadej Debevec, Matthew D. DeLang, Alexandre Dellal, Gürhan Dönmez, Tarak Driss, Juan David Peña Duque, Cristiano Eirale, Mohamed Elloumi, Carl Foster, Emerson Franchini, Andrea Fusco, Olivier Galy, Paul B. Gastin, Nicholas Gill, Olivier Girard, Cvita Gregov, Shona Halson, Omar Hammouda, Ivana Hanzlíková, Bahar Hassanmirzaei, Kim Hébert-Losier, Hussein Muñoz Helú, Tomás Herrera-Valenzuela, Florentina J. Hettinga, Louis Holtzhausen, Olivier Hue, Antonio Dello Iacono, Johanna Ihalainen, Carl James, Saju Joseph, Karim Kamoun, Mehdi Khaled, Karim Khalladi, Kwang Joon Kim, Lian-Yee Kok, Lewis MacMillan, Leonardo Jose Mataruna-Dos-Santos, Ryo Matsunaga, Shpresa Memishi, Grégoire P. Millet, Imen Moussa-Chamari, Danladi Ibrahim Musa, Hoang Minh Thuan Nguyen, Pantelis T. Nikolaidis, Adam Owen, Johnny Padulo, Jeffrey Cabayan Pagaduan, Nirmala Panagodage Perera, Jorge Pérez-Gómez, Lervasen Pillay, Arporn Popa, Avishkar Pudasaini, Alizera Rabbani, Tandiyo Rahayu, Mohamed Romdhani, Paul Salamh, Abu-Sufian Sarkar, Andy Schillinger, Heny Setyawati, Navina Shrestha, Fatona Suraya, Montassar Tabben, Khaled Trabelsi, Axel Urhausen, Maarit Valtonen, Johanna Weber, Rodney Whiteley, Adel Zrane, Yacine Zerguini, Piotr Zmijewski, Helmi Ben Saad, David B. Pyne, Lee Taylor, and Karim Chamari

Purpose: To investigate differences in athletes' knowledge, beliefs, and training practices during COVID-19 lockdowns with reference to sport classification and sex. This work extends an initial descriptive evaluation focusing on athlete classification. **Methods:** Athletes (12,526; 66% male; 142 countries) completed an online survey (May–July 2020) assessing knowledge, beliefs, and practices toward training. Sports were classified as Team sports (45%), Endurance (20%), Power/technical (10%), Combat (9%), Aquatic (6%), Recreational (4%), Racquet (3%), Precision (2%), Parasports (1%), and Others (1%). Further analysis by sex was performed. **Results:** During lockdown, athletes practiced bodyweight-based exercises routinely (67% females and 64% males), ranging from 50% (Precision) to 78% (Parasports). More sport-specific technical skills were performed in Combat, Parasports, and Precision (~50%) than other sports (~35%). Most athletes (range: 50% [Parasports] to 75% [Endurance]) performed cardiorespiratory training (trivial sex differences). Compared to prelockdown, perceived training intensity was reduced by 29% to 41%, depending on sport (largest decline: ~38% in Team sports, unaffected by sex). Some athletes (range: 7%–49%) maintained their training intensity for strength, endurance, speed, plyometric, change of direction, and technical training. Athletes who previously trained ≥5 sessions per week reduced their volume (range: 18%–28%) during lockdown. The proportion of athletes (81%) training ≥60 min/session reduced by 31% to 43% during lockdown. Males and females had comparable moderate levels of training knowledge (56% vs 58%) and beliefs/attitudes (54% vs 56%). **Conclusions:** Changes in athletes' training practices were sport-specific, with little-to-no sex differences. Team-based sports were generally more susceptible to changes than individual sports. Policy makers should provide athletes with educational resources to facilitate remote and/or home-based training during lockdown-type events.

Keywords: crowdsourced data, multinational sample, online survey, perception, remote training

Severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) and the resulting COVID-19 pandemic transformed day-to-day

life globally.¹ National and/or local authorities adopted (and readopted) varying restrictive measures to curb virus spread, including closure of borders and educational institutions, alongside restriction of commercial activities.² Global sporting calendars were severely disrupted at all levels, notably the postponement of the Tokyo 2020 Summer Olympics. Sport-specific training and recovery facilities

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alongside athlete support services (eg, sports science, sports medicine and allied health services) were, at best severely restricted, and at worst, unavailable.^{3,4} Consequently, athletes were housebound for prolonged periods, drastically modifying their daily lives and training practices.^{5,6} Additionally, sleep,¹ mental health,⁷ and nutrition⁸ were all impacted.

Restrictive measures including social distancing disrupted team, and contact sport athletes' ability to practice sport-specific and/or contact intensive skills (eg, rucking, mauling, scrummaging and tackling in rugby,⁹ or general team technical/tactical work).¹⁰ Training intensity in professional handball players was reduced, with females showing a greater reduction in weekly training days and hours than males,¹¹ suggesting differential effects of the lockdown on athlete training due to sex. Training volume and intensity among professional cyclists during a 7-week home confinement was reduced alongside maximal power output during 5- and 20-minute trials.¹² Weight-categorized athletes experienced challenges in maintaining optimal body mass and composition during lockdown.¹³ Aquatic sports were almost completely "prohibited" and thus, likely, severely compromised.¹⁴ Concerningly, individuals with disabilities (eg, Paraspport athletes) who often require highly specialized and/or bespoke training resources (equipment and expertise) were particularly disadvantaged during the lockdown.¹⁵ Holistically, it is clear near-all athletes (recreational, elite, or otherwise) were challenged practically and psychologically to maintain their "normal" training programs as a consequence of lockdowns.

During the first global lockdown, athletes were inclined to perform home-based strength training activities such as body-weight exercise, and use alternative endurance training modalities such as a cycle ergometry.^{6,16} These strategies, although preferable to training cessation, have questionable effectiveness in providing sufficient training stimuli (whether for maintenance or to drive adaptation) for high-level athletes. Given this unexpected autonomy, many athletes' individual knowledge and attitude toward training likely impacted their self-regulation¹⁷ of training variables such as intensity, volume, and training mode. These individual variations within- and between-sports may have impacted the way athletes attempted to mitigate detraining effects during lockdown. Only scant information has been reported about athletes' knowledge, beliefs, and attitudes toward training, and in turn how the understanding of these issues "shaped" training modifications during lockdown.

As alluded to above, potential sex differences regarding training maintenance during lockdown may have been present; however, this assertion is based on a single sport (ie, handball), and the question has not been explored extensively. That said, female athletes during lockdown were more likely to experience mental health issues compared with male athletes, including depressive feelings, energy loss, and reduced motivation, according to one dataset.⁶ Specifically, female athletes tended to be more anxious¹⁸ and reported mood disruptions related to increased perceived stress and dysfunctional psychobiosocial states.¹⁹ Furthermore, female athletes with underlying medical conditions (eg, menstrual dysfunction such as endometriosis) may have had reduced access to appropriate medical care during the lockdown period.²⁰ When considering the challenges female athletes experienced during lockdown, lower classification athletes appear more likely to be disadvantaged.²¹

This study assessed the knowledge, beliefs/attitudes, and practices toward training and its interruption during the 2020 early COVID-19 lockdown period. Specifically, how these issues were

moderated by sport classification and sex was explored. The data will extend the initial analyses of the study focusing on overall outcomes and athlete classification²¹ to provide specific evidence to support individuals and sporting teams, sport governing bodies, and governments in developing practical guidelines, coaching practices, educational resources for athletes, and/or policies and procedures to optimize their responses to future restrictions or lockdowns.

Methods

Participants

A sample of athletes (n = 12,526; representing 142 countries/territories across 6 continents) participated in the current study. Participant eligibility is described elsewhere (open access).²¹ Informed consent was provided by participants under ethical approval from: (1) University of Melbourne, Australia (HREC No. 2056955.1); (2) Qatar University, Qatar (QU-IRB 1346-EA/20); and (3) University of Cassino e Lazio Meridionale, Italy (10031), in the spirit of the Declaration of Helsinki.

Design

A within-subject, cross-sectional, questionnaire study design was utilized providing further novel analyses from the collaborative ECBATA (Effects of Confinement on knowledge, Beliefs/Attitudes, and Training in Athletes) project,²¹ specifically, whether COVID-19 lockdown effects on athlete training were moderated by sport classification and/or sex. The full questionnaire is available in open access format.²¹

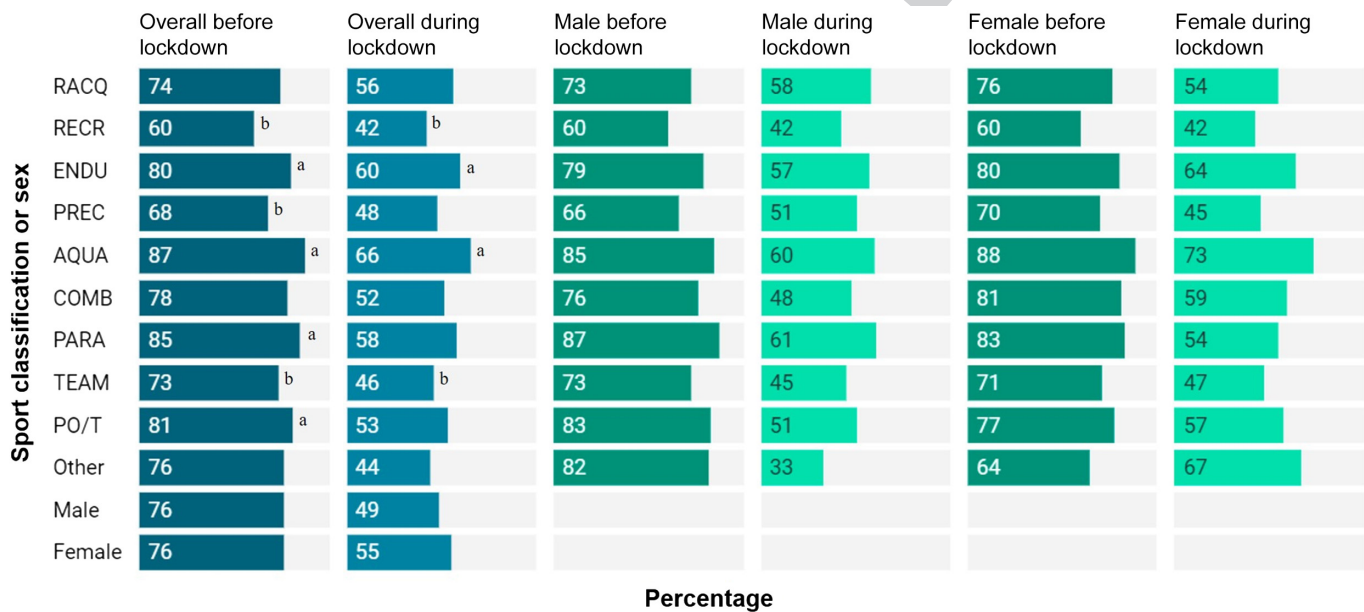
Procedures

An online survey (35 different languages) was disseminated via Google Forms from May to July 2020 (50 d). The survey was distributed and promoted via email, personal/group messaging applications, and social media through the professional networks of the research team. Question data were converted directly into standardized codes/numbers, and checked for veracity to facilitate statistical modeling. Cronbach alpha of .82 to .97²¹ demonstrated *good to excellent* reliability of the questionnaire.²² The survey was developed initially by Washif and Chamari, then reviewed and revised by the wider authorship team, involving >100 researchers from >60 countries. The 59 questions were related to athletes' training knowledge, beliefs/attitudes, and practices, as described elsewhere.²¹ Beliefs and attitudes are individually held; belief is related to expression of what is thought or believed; attitude is a psychological tendency or mental predisposition which influences how an individual behaves optimistically toward key issues.²¹ Sport classification was self-report by athletes, yielding 108 different sports (and disciplines within sports). Some sports were specifically reported, for example, BMX, road or track cycling (for cycling), and marathon, road running, or athletics (for athletics). For athletes who reported more than one sport, the first identified sport was considered the "main" sport. For sex comparisons only, 31 athletes who indicated a nonbinary "sex" or did not indicate "sex" (male/female) were excluded to enable binary statistical comparisons. Where sex comparisons are stated/inferred, this indicates they have been completed in a binary whole sample manner. Sport-specific comparisons by sex within each sport classification can be found in Table 1, Figures 1–4, and Supplementary Table S1 (available online).

Table 1 Comparison of Knowledge and Beliefs/Attitudes Related to Training Interruptions During Lockdown, Based on Sport Classification (n = 12,526) and Sex (n = 12,495)

			Knowledge		Beliefs/attitudes	
	Knowledge	Beliefs/attitudes	Male	Female	Male	Female
	(0%–100%)	(0%–100%)	(0%–100%)	(0%–100%)	(0%–100%)	(0%–100%)
Aquatic	59 (18)	56 (20)	57 (19)	60 (16)	55 (22)	57 (19)
Combat	57 (18)	54 (21)	57 (19)	57 (17)	53 (22)	55 (20)
Endurance	57 (17)	57 (22)	56 (18)	58 (16)	57 (23)	59 (21)
Parasports	60 (16)	57 (19)	63 (14)	57 (19)	57 (19)	58 (20)
Power/technical	56 (20)	54 (24)	55 (21)	58 (18)	53 (25)	55 (22)
Precision	51 (18)	51 (22)	53 (18)	50 (18)	53 (20)	49 (23)
Racquet	56 (18)	56 (22)	56 (18)	56 (17)	56 (23)	57 (21)
Recreational	51 (21)	48 (29)	50 (21)	53 (19)	46 (29)	52 (28)
Team	57 (19)	55 (23)	56 (19)	59 (17)	54 (24)	57 (22)
Other	50 (19)	51 (21)	49 (20)	53 (17)	49 (22)	55 (19)
Male	56 (19)	54 (24)				
Female	58 (17)	56 (22)				

Q11 Note: Data are presented as mean (SD). Scoring threshold: ≥70% = good, >50% to <70% = moderate, and ≤50% = poor.



Q12 **Figure 1** — Training frequency of ≥5 times per week based on sport classification and sex before and during lockdown (n = 11,626). Ordered from smallest to largest reductions. Percentage, within sex or within sports, represents “yes” answer, relative to “no” answer. AQUA indicates Aquatic; COMB, Combat; ENDU, Endurance; Other, Others; PARA, Parasports; PO/T, Power/technical; PREC, Precision; RACQ, Racquet; RECR, Recreational; TEAM, Team. Note: Changes from before lockdown to during lockdown for all variables were significant ($P < .05$) except “Other Female.” ^aSignificantly higher; ^bsignificantly lower at $P < .05$.

Subgroups for (1) able-bodied and (2) Para-athletes (ie, *Parasports*; defined as individuals requiring special assistance, or having a disability) were coded and analyzed separately due to sampling power requirements. Using a *best-fit approach* and aggregation, able-bodied sports were classified into 9 sport classifications and differentiated further by competitive level and recreational (ie, *Recreational*; noncompetitive participation or physical activities, usually for leisure, health, or work-related) sports. Similarly, competitive sports were further subgrouped, as follows:

(1) self-dependent training in nature without or with own equipment, and those relatively longer in duration (ie, *Endurance*; eg, triathlon, cross country, and road cycling); (2) self-dependent training with technical concerns, and/or specific equipment not usually owned or easily accessible (ie, *Power/technical*; eg, field events in athletics, weightlifting, and CrossFit®); (3) interactive or dependent on teammates (ie, *Team*; eg, hockey, rugby, and volleyball) or sparring/fighting (ie, *Combat*; eg, Muay Thai, Ju-jitsu, and wrestling); (4) one or more combinations of these criteria and

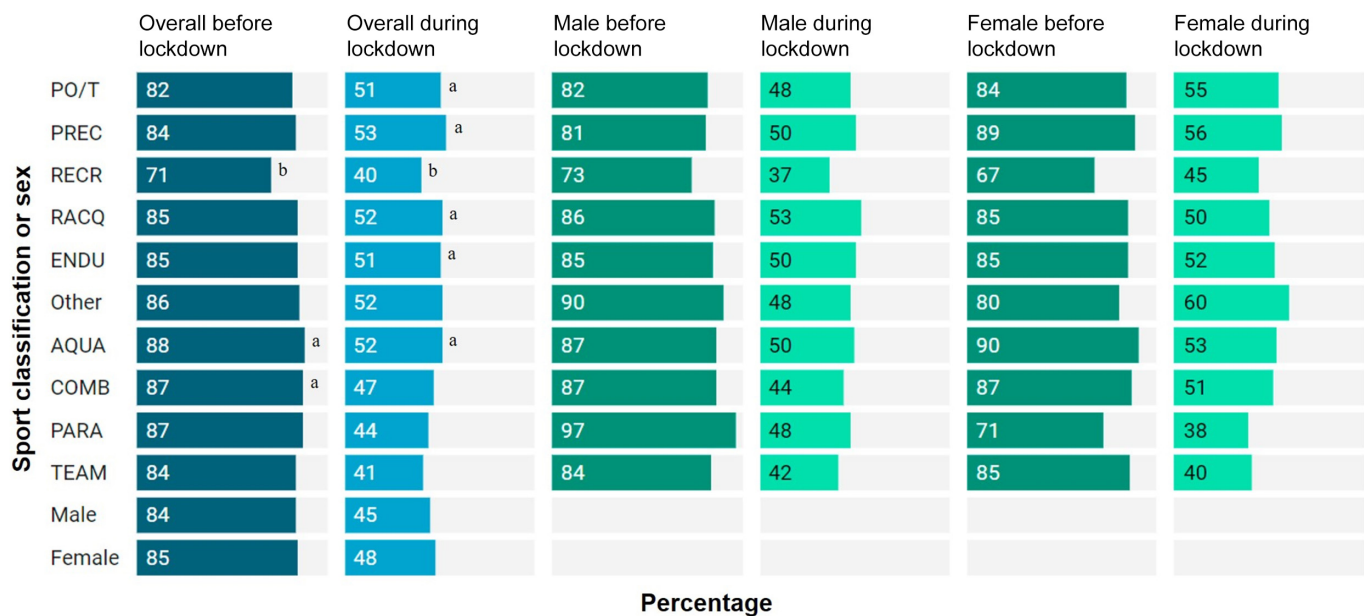


Figure 2 — Training duration of ≥ 60 minutes per session based on sport classification and sex before and during lockdown ($n = 12,241$). Ordered from smallest to largest reductions. Percentage, within sports or within sex, represents “yes” answer, relative to “no” answer. AQUA indicates Aquatic; COMB, Combat; ENDU, Endurance; Other, Others; PARA, Parasports; PO/T, Power/technical; PREC, Precision; RACQ, Racquet; RECR, Recreational; TEAM, Team. Note: Changes from before lockdown to during lockdown for all variables were significant ($P < .05$) except “Other Female.”^aSignificantly higher; ^bsignificantly lower at $P < .05$.

type of sport, for example, water-based (ie, *Aquatic*; eg, water polo, canoe, and sailing), racquet-based (ie, *Racquet*; eg, tennis, badminton, and squash), and target-based (ie, *Precision*; eg, archery, shooting, and bowling); and (5) other than the 7 classifications for competitive sports, or relatively competitive sports, but hardly participated (ie, *Other*; eg, wheel gymnastic and aerial silks) (Figure 5).

The knowledge section comprised 10 questions (9 scored questions), using a 5-point Likert scale (1 = strongly agree; 5 = strongly disagree; with an addition to “don’t know” option).²¹ The belief and attitude section comprised 14 questions (same 5-point Likert scale), with 7 scored questions. Correct (for knowledge) or positive (for beliefs/attitudes) answers (eg, strongly agree/agree or strongly disagree/disagree with a statement) were scored as “1.” The other answers received a score of “0” (including the statements “neutral” or “don’t know”). The total score (converted into percentage) was used to rank the level of knowledge and beliefs/attitudes based on previously established thresholds: $\geq 70\%$ as good, $\geq 51\%$ to $< 70\%$ as moderate, and $\leq 50\%$ as poor for athlete/classification comparisons.²¹ The practice section was comprised of 11 questions involving an array of question styles to establish training practices, including: (1) selecting one or more predefined answers, (2) comparing related prelockdown with during-lockdown effects on training practices, (3) yes or no, and (4) subquestions including a free-text cell to capture details.²¹

Statistical Analysis

All data were coded with statistical analyses performed using SPSS (version 26). Data are presented using a variety of appropriate descriptive statistics, including frequencies, percentages, and mean (SD). Knowledge and beliefs/attitudes scores across sex and sport classifications were compared using an independent t test and 1-way analysis of variance with Bonferroni post hoc

test, respectively. Relationships between categorical variables were assessed using chi-square (χ^2) test for independence. Subsequently, analysis of adjusted residuals was performed to identify which subgroups contributed the most (*residual greater than 1.96; ie, significantly higher*) or the least (*residual less than -1.96; ie, significantly lower*) to the relationships, which corresponds to $P < .05$. A McNemar–Bowker test was utilized to compare frequency and duration of training before versus during lockdown within athletes. The odds ratio, with a 95% confidence interval, was used to estimate the strength of the relationship of bivariate variables by sex. Only those odds ratios were considered where the 95% confidence interval did not include 0.91 to 1.10 range (10% change, based on $1/1.1 = 0.91$ and $1 \times 1.1 = 1.10$). A difference of $< 10\%$ was deemed unclear for both sport and sex comparison. A P value of $< .05$ was considered significant.

Results

Demographic Characteristics

A majority of the participants were involved in Team (45%) or Endurance (20%) sports, with two thirds of male athletes (66%) (Table 2).

Training Knowledge and Beliefs/Attitudes

Overall scores for knowledge and beliefs/attitudes toward training during lockdown, for both male and female athletes, are presented in Table 1. For both scoring scales, male and female athletes had a *moderate* level of knowledge and beliefs/attitudes. The 9 questions (and aggregated answers) for knowledge toward training according to sport classification and sex are provided in Supplementary Tables S2 and S3 (available online). The corresponding 7 questions for beliefs/attitudes toward training are provided in Supplementary

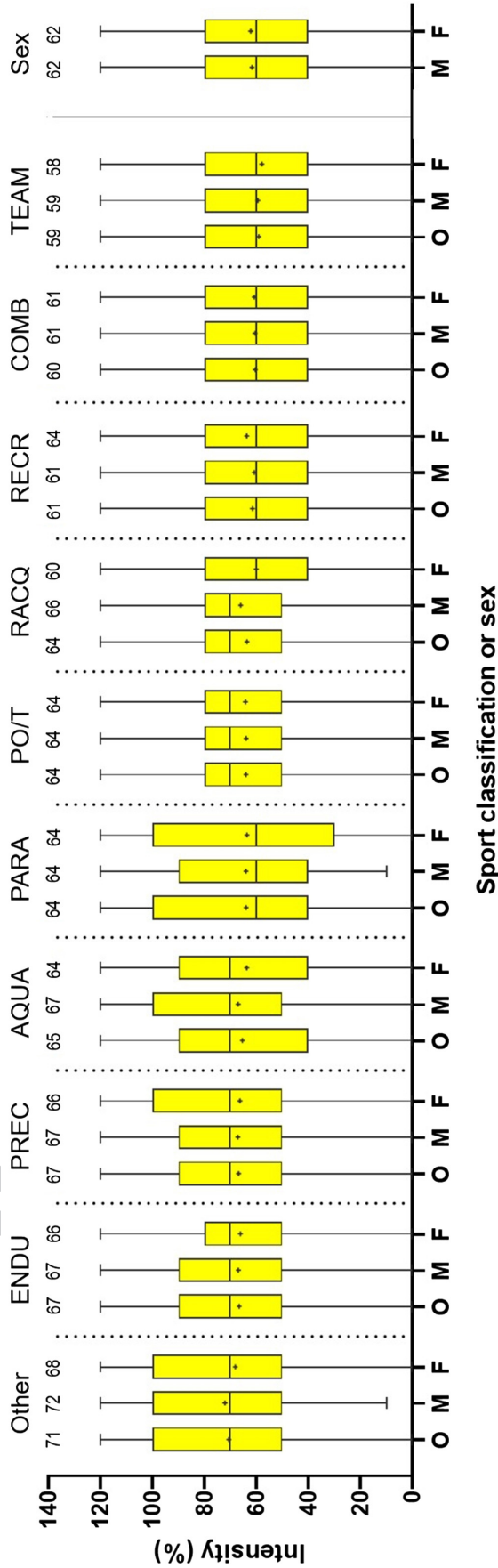


Figure 3 — Training intensity during lockdown session based on sport classification and sex. Question: Do/did you maintain your prelockdown intensity for sports-specific training (practicing your sport) during the lockdown? Can you estimate how much in percentage? (100% represents the same intensity as before the lockdown). Ordered from smallest to largest reductions. Data are mean (SD). AQUA indicates Aquatic; COMB, Combat; ENDU, Endurance; F, female; M, male; O, overall data; Other, Others; PARA, Paraspports; PO/T, Power/technical; PREC, Precision; RACQ, Racquet; RECR, Recreational; TEAM, Team. Note: All comparisons between male and female athletes were significant at $P < .001$. The whisker plot includes 5 number-summary (lowest to highest): minimum, first quartile, median, third quartile, and maximum. The maximum or minimum number in the data set, respectively, is shown by the upper extreme or lower extreme of the whisker/chart (excluding outliers). Upper (third) and lower (first) quartiles, respectively, are the 75th and 25th percentiles. The median (middle of data set) is shown as a line in the center of each box. +Mean values.

A - Do/did you have sufficient space/access for (training):

Sport classification or sex	Technical, overall	Technical, male	Technical, female	Cardio, overall	Cardio, male	Cardio, female	Strength, overall	Strength, male	Strength, female
	AQUA	53 ^b	53	52	81 ^a	84	78 [*]	61	63
COMB	68 ^a	66	73 [*]	74	74	76	61	60	63
ENDU	59	58	60	84 ^a	85	84	66 ^a	65	67
PARA	44 ^b	41	50	63 ^b	57	71	60	69	44 [*]
PO/T	61 ^a	61	61	75	75	74	61	61	60
PREC	63 ^a	60	67	73	71	75	60	54	66
RACQ	50 ^b	46	54	79	82	75	64	62	66
RECR	63 ^a	60	68	72 ^b	78	63 [*]	55 ^b	52	61
TEAM	54 ^b	53	56	73 ^b	73	74	62	63	62
Other	62	57	69	74	80	61	59	52	75
Male	56			76			63		
Female	59			76			63		

B - Do/did you have necessary equipment to train for:

Sport classification or sex	Technical, overall	Technical, male	Technical, female	Cardio, overall	Cardio, male	Cardio, female	Strength, overall	Strength, male	Strength, female
	AQUA	54	55	53	82 ^a	86	79 [*]	51	53
COMB	66 ^a	63	72 [*]	73	72	74	52	51	54
ENDU	56	54	59 [*]	86 ^a	85	86	53 ^a	53	54
PARA	52	55	47	61	58	65	53	63	38 [*]
PO/T	53	51	56	73	72	76	54	53	55
PREC	61 ^a	57	64	68 ^b	67	68	47	48	45
RACQ	50	51	50	78	79	76	50	53	54
RECR	53	47	63 [*]	70 ^b	73	64	54	45	48
TEAM	51 ^b	50	54 [*]	69 ^b	68	72 [*]	50 ^b	51	49
Other	56	51	64	80	79	82	55	51	63
Male	52			73			52		
Female	58			76			51		

Percentage

Figure 4 — Reported practices for space/access and equipment to training based on sport classification and sex (n = 11,451). Question: Do/did you have (A) sufficient space/access, and (B) necessary equipment to train for? Percentage, within sex or within sports, represents “yes” answer, relative to “no” answer. AQUA indicates Aquatic; COMB, Combat; ENDU, Endurance; Other, Others; PARA, Parasports; PO/T, Power/technical; PREC, Precision; RACQ, Racquet; RECR, Recreational; TEAM, Team. ^aSignificantly higher; ^bsignificantly lower at $P < .05$. ^{*}Significantly higher than male.

Tables S4 and S5 (available online), respectively. Finally, the questions and answers related to knowledge and beliefs/attitudes according to sport classification and sex are shown in Supplementary Tables S6 and S7, respectively (available online).

Training Practices

The most frequent purpose of the athlete’s training during lockdown, regardless of sport classification, was to maintain or develop general fitness and health (Table 3), with males (81%) and females (85%) displaying high training frequency (Table 4). The training

program was either prescribed by the athletes themselves, the coach, or a combination of both, but male athletes were more likely ($P < .001$) to perform their own training program than female athletes during lockdown. Both male (80%) and female (79%) athletes generally trained alone, with Precision sports to a lesser degree than other sports ($P < .05$) (Table 3). Bodyweight-based exercises were most consistently performed during lockdown (67% and 64% for female and male athletes, respectively [$P < .001$]); ranging from 50% (Precision sports) to 78% (Parasports). Cardio-respiratory training was also consistently performed by most athletes, ranging from 50% in Parasports to 75% in Endurance

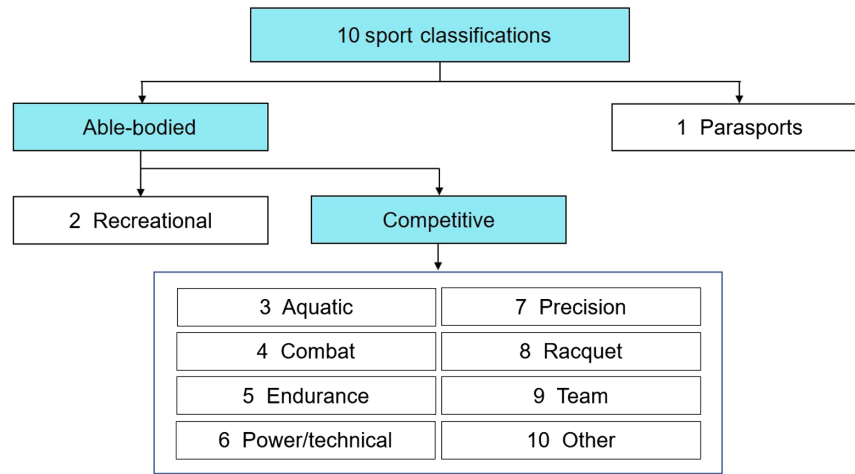


Figure 5 — Flow diagram outlining sport classification process.

Table 2 Demographic Characteristics of Participants by Sport Classification and Sex

	Total (n = 12,526)	Total, %	Male proportion (n = 8265), %	Female proportion (n = 4230), %	Between- sports proportion (male), %	Between- sports proportion (female), %
Team	5600	45	71	29	48	38
Endurance	2465	20	66	34	20	20
Power/ technical	1212	10	61	39	9	11
Combat	1188	9	64	36	8	10
Aquatic	704	5	51	49	4	8
Recreational	469	4	63	37	4	4
Racquet	405	3	59	41	3	4
Precision	313	2	53	47	2	3
Parasports	95	1	62	38	1	1
Other	75	1	65	35	1	1
		100			100	100

Note: Between-sports proportion entails a comparison between all sports within a specific sex only. Thirty-one athletes indicated a nonbinary “sex” or did not indicate “sex” (male/female) and were excluded for sex comparison.

sports. Other exercise forms (eg, strength and plyometric training) were less regularly performed (~20%–50%, depending on sport classification), but sport-specific technical skills were more regularly performed (~50%) in Combat, Parasports, and Precision compared with the other sports (~35%) ($P < .05$). Less than half of the athletes (7%–49%, depending on sport classification) were able to maintain the same intensity during strength, endurance, speed, plyometric, change of direction, and technical training when compared with prelockdown (Table 3). Most athletes, 85% of females and 80% of males, reported being able to perform warm-up and stretching with the same prelockdown intensity during the lockdown (Table 4).

Comparisons of weekly training frequency, session duration, and training intensity before and during lockdown between sports and sex are shown in Figures 1, 2, and 3, respectively. During lockdown, the frequency of training dropped for all sport classifications ($P < .001$). Similarly, the number of athletes performing >60 min/session training was much lower during

lockdown for all sport classifications, ranging from 31% to 43% of the athletes. Team sports showed the highest reduction in training intensity (59%), a significantly larger reduction than reported for Aquatic, Endurance, Power/technical, and Precision sports. Within each sport, training frequency (except “Other Female”) and duration from before to during lockdown in male and female athletes were reduced ($P < .05$). As a whole sample, reduction in training intensity was the same for male and female athletes (~38%); with a disparity of 0% to 6% between males and females within different sports.

Figure 4 shows that 44% to 84% of the athletes reported sufficient access/space and the necessary equipment to train during lockdown, depending on sport classification. Overall, a higher degree of access/space and necessary equipment was reported for cardiorespiratory training compared with strength and technical training. Male and female athletes were similarly affected (ie, ranging from 3% to 6% difference between sexes, $P < .05$) in terms of technical (access/space/necessary equipment) and cardiovascular (necessary

Table 3 Athlete Practices During COVID-19 Lockdown Based on Sport Classification

	Percentage of respondents									
	AQUA	COMB	ENDU	PARA	PO/T	PREC	RACQ	RECR	TEAM	Other
1. What are/were your general purpose(s) of training during the lockdown? (n = 12,385)										
M/d general fitness and health*	87 ^a	84	85 ^a	90	78 ^b	78 ^b	87 ^a	82	82 ^b	73 ^b
M/d skills/technique*	37 ^b	55 ^a	38 ^b	55 ^a	44	58 ^a	37 ^b	31 ^b	43	51
M/d strength and power*	54	53	52 ^b	54	55	56	55	46 ^b	56 ^a	55
M/d muscular endurance*	55	58 ^a	54	59	52 ^b	56	56	49 ^b	55	44
M/d abdominal strength*	55 ^a	46	49	59 ^a	47	35 ^b	49	45	48	43
M/d aerobic fitness*	57 ^a	50	56 ^a	51	49	46	49	48	47 ^b	43
M/d general flexibility*	49 ^a	50 ^a	45	47	43	35 ^b	44	41	42 ^b	43
Improve muscle balance*	38	39	35	34	37	38	37	32	37	33
Weight management*	52 ^a	51 ^a	48	51	44	48	50	54	47	41
2. Who is prescribing/prescribed the training program during the lockdown? (n = 12,351)										
Own training program*	35 ^b	47 ^a	41	31 ^b	39 ^b	39	45	39	45	53
From coach or trainer*	43 ^a	40	38 ^b	57 ^a	44 ^a	44	40	39	39	29
Combination of above*	44 ^a	36	38	38	35	46 ^a	36	33	35 ^b	25 ^b
Found from an external source*	26	23	22 ^b	12 ^b	20 ^b	23	30 ^a	34 ^a	28 ^a	23
3. Do/did you train (with)? (n = 12,347)										
Alone*	80	80	82 ^a	85	80	73 ^b	77	79	79	83
Partners, similar-level fitness*	34 ^a	29	30	27	28	37 ^a	34 ^a	23 ^b	28 ^b	29
Partners, different-level fitness*	19	18	22	20	17 ^b	20	19	16	18	20
4. What are the type of exercises that you are doing/have been doing consistently (at least twice a week) during lockdown? (n = 12,522)										
Bodyweight-based/limited equipment*	70 ^a	65	65	78 ^a	63	50 ^b	64	62	66	51 ^b
Weightlifting/strength training*	37 ^a	34	27 ^b	40	40 ^a	27	33	24 ^b	32	35
Technical skills (sport specific)*	36 ^b	53 ^a	33 ^b	51 ^a	35	47 ^a	34	31 ^b	35 ^b	37
Imitation of techniques*	30 ^a	42 ^a	22 ^b	26	24	30 ^a	30 ^a	22	21 ^b	31
Q14 Cardio training, including HIIT*	67 ^a	51 ^b	75 ^a	50	54 ^b	52 ^b	63	55	54 ^b	56
Plyometric training	24	29 ^a	26	12 ^b	29 ^a	17 ^b	27	19 ^b	25	29
5. What are the types of specific training you are/were able to do with the same intensity during the lockdown (very similar to prelockdown)? (n = 12,522)										
Warm-up and stretching*	85 ^a	84 ^a	80	85	83	79	79	80	81	78
Weightlifting/strength training*	33	33	30 ^b	41	36 ^a	32	34	27	34	30
Plyometric training*	27	35 ^a	31	14 ^b	32	22 ^b	28 ^b	24	30	28
Technical skills (sport-specific)*	29	46 ^a	29	39	30	45 ^a	29	29	28 ^b	38
Speed training*	23 ^b	29 ^a	29 ^a	31	23 ^b	20 ^b	31	24	27	20
Speed endurance*	30	30	33 ^a	28	25 ^b	17 ^b	30	26	27 ^b	23
Long endurance*	44 ^a	35 ^b	49 ^a	32	37	33	39	34 ^b	35 ^b	38
Interval/intermittent training*	41 ^a	33	45 ^a	33	36	31	38	38	30	30
Change of directions*	8 ^b	20 ^a	12 ^b	9	9 ^b	7 ^b	16	15	18 ^a	7 ^b

Abbreviations: AQUA, Aquatic; COMB, Combat; ENDU, Endurance; M/d, maintain or develop; Other, Others; PARA, Parasports; PO/T, Power/technical; PREC, Precision; RACQ, Racquet; RECR, Recreational; TEAM, Team. Note: For all questions, athletes were allowed to select multiple answers. Percentage, within sport classification, represents “yes” answer, relative to “no” answer. This table is in conjunction with Supplementary Table S1 (available online) that includes details of male and female athletes; answer’s selections are shortened, and long version can be seen in Table 4.

^aSignificantly higher; ^bsignificantly lower at $P < .05$.

*Significant relationship with sport classification.

equipment) training. Some disparity in sex distribution is evident for selected variables in different sport classifications (Figure 4).

Discussion

Most of the observed lockdown mediated changes in training practices of athletes were likely mediated by the nature of the

sports themselves. Individual and less equipment-intensive sports (eg, Endurance sports) were easier to maintain during lockdown than more technically demanding sports (eg, Racquet and Team sports) requiring a partner, teammates, and/or specialist equipment. In some sports, shifting/adaptation of training practices was necessary to provide specific training benefits. Within this context, Combat sport athletes implemented more practical fitness exercises such as plyometric training, skills, and technical development,

Table 4 Practices During COVID-19 Lockdown by Athletes Based on Sex

	Male, %	Female, %	OR (95% CI) ^a
1. What are/were your general purpose(s) of training during the lockdown? (n = 12,385)			
Maintain or develop general fitness and health	81	85	0.78 (0.70–0.86)
Maintain or develop skills/technique	41	45	0.84 (0.78–0.91)
Maintain or develop strength and power	54	55	0.97 (0.90–1.05)
Maintain or develop muscular endurance	54	57	0.88 (0.82–0.95)
Maintain or develop abdominal strength	46	52	0.80 (0.74–0.86)
Maintain or develop aerobic fitness	50	50	0.99 (0.92–1.06)
Maintain or develop general flexibility	41	48	0.76 (0.70–0.82)
Improve muscle balance	35	39	0.87 (0.80–0.94)
Weight management	46	51	0.84 (0.78–0.90)
2. Who is prescribing/prescribed the training program during the lockdown? (n = 12,351)			
Own training program	46	37	1.46 (1.35–1.57)
Training program from my coach or trainer	39	42	0.88 (0.82–0.95)
Combination of own training and my coach/trainer	35	40	0.79 (0.73–0.85)
Found training material from an external source: online/social media/TV, a friend, etc	23	30	0.72 (0.66–0.79)
3. Do/did you train? (n = 12,347)			
Alone	80	79	1.03 (0.94–1.13)
In a small group of partners of equal athletic capacity	29	30	0.92 (0.85–1.00)
With family members or friends with little athletic capacity	18	21	0.81 (0.74–0.89)
4. What are the type of exercises that you are doing/have been doing consistently (at least twice a week) during lockdown? (n = 12,522)			
Bodyweight-based exercises with limited equipment	64	67	0.84 (0.78–0.91)
Weightlifting (strength) training	32	32	1.00 (0.92–1.08)
Technical skills (sport specific)	36	38	0.93 (0.86–1.01)
Imitation or simulation of the techniques	24	26	0.90 (0.82–0.98)
Cardiovascular training, including HIIT	60	61	0.88 (0.82–0.95)
Plyometric training (repeated jumping)	25	27	0.90 (0.83–0.98)
5. What are the types of specific training you are/were able to do with the same intensity during the lockdown (very similar to prelockdown)? (n = 12,522)			
Warm-up and stretching	80	85	0.72 (0.65–0.79)
Weightlifting (strength) training	34	31	1.16 (1.07–1.26)
Plyometric training (eg, repeated jumping)	29	32	0.86 (0.79–0.93)
Technical skills (sport-specific)	30	33	0.88 (0.81–0.95)
Speed training	27	26	1.06 (0.98–1.16)
Speed endurance	29	27	1.08 (1.00–1.18)
Long endurance	40	37	1.13 (1.05–1.22)
Interval/intermittent training	34	37	0.88 (0.81–0.95)
Change of directions	15	14	1.08 (0.98–1.21)

Abbreviations: CI, confidence interval; OR, odds ratio. Note: For all questions, athletes were allowed to select multiple answers; valid percentage computed excluding missing values, within sex, represents “yes” answer, relative to “no” answer. Bolded values indicate 95% CI outside of 0.91 to 1.10 range (10% change or “clear” difference).

^aRatio of participant knowledge among males using “females” as reference.

while Aquatic sports athletes were self-adjusting by amplifying their prelockdown dry-land workouts, including cardiorespiratory-based fitness. Based on overall data, the pandemic subjectively affected the training routines of male and female athletes similarly, although these differences were slightly disproportionate in some cases, for example, mental aspect (44% males vs 48% females, respectively), including inconsistencies within sports, for example, Aquatic and Parasports. Although some sex differences were observed in overall data (0%–6%), the magnitudes are probably not meaningful in practical terms. The scores or perceptions in training knowledge and beliefs/attitudes between sexes were

similarly (~50%–60%) rated as *moderate* by the employed criteria. The sex data suggest that future lockdown-type events do not require policy or guidance to be wholly modified based on sex (although there are some nuances to consider), while sport classification would benefit from such consideration and individualization.

Sports can be classified across a continuum ranging from individual to interactive, the latter involving teammates and/or direct opponents.²³ Seemingly, these characteristics modified athletes training modifications in response to lockdown. Indeed, more Endurance athletes trained alone during lockdown than other sports. The training of Endurance athletes typically involves a

combination of low-intensity continuous work (below anaerobic threshold) and high-intensity interval training (at or above anaerobic threshold).²⁴ This training can be achieved using a home-based treadmill, cycle rollers, or a rowing ergometer, if outdoor training is not viable. Interestingly, 40% of Power/technical athletes were able to implement strength training, more than other sports, which also encompassed prelockdown training intensity (36%) and plyometric training (32%). Evidently, some athletes were already in possession of, or were able to prepare/buy/borrow the necessary equipment (specialized or otherwise) prior to lockdown.²⁵ Concerning training facility access, elite athletes were less affected by lockdowns than their lower-level counterparts.²¹ In contrast, Combat sport athletes had to change their training focus and methods to a larger extent given the higher probability of virus transmission during close contact interactions.²⁶ Consequently, these athletes employed a greater focus on skills/technique development, combat simulations, plyometric training, endurance training, and weight management during lockdown.

Despite pool closures, Aquatic athletes found functional substitutes to their routines, with relatively more Aquatic athletes training for general fitness and health (87%) compared with others (eg, Power/technical [78%]). These Aquatic sports athletes adopted a wide range of training modalities, including bodyweight-based exercises, especially females (eg, abdominal strength [aquatic female 63% vs male 48%] and flexibility [female 56% vs male 44%]), strength training, technical simulation, and cardiovascular training, while observing weight management (female 57% vs male 47%). Performing dry-land activities may maintain fitness during pool closures and could enhance selected performance components when resuming regular aquatic training. For example, enhanced strength and power in the lower limbs may improve the starting dive of swimmers.¹⁴ Similarly, Precision sports athletes found substitutes for their prelockdown training. Unable to train with their rifles, archers, or ball/pins, many athletes from these sports utilized strength training (40%) to enhance their muscular abilities in place of refining their skills/techniques, using a program provided by their coaches, or self-prescribed. These activities could help athletes improve selected components of their sports performance via increased precision, constancy, and stability (eg, for shooting) as a result of improved muscular strength and aerobic capacity.²⁷ It is noteworthy that within a small sample in Paraspports, a higher proportion of athletes (78%) performed bodyweight-based exercises, with some sex disparity evident, that is, 85% females and 67% males. During lockdown, resistance training can be performed in different ways to achieve specific objectives, albeit necessitating some creativity using different types of training, dependent on location.²⁵ Nevertheless, despite being able to maintain elements of routine practices, some key variables such as training intensity were likely compromised during lockdown.²⁵ Clearly, athletes wishing to elicit specific adaptive responses in terms of training goals must manipulate or modify the key training variables accordingly, including training duration, intensity, type of exercise, and frequency. These adaptations may lack efficacy regarding maintenance or development of physical and/or technical attributes.

Insufficient and/or inappropriate training stimuli in key training variables such as intensity and frequency can lead to de-training.^{28,29} In the current study, during lockdown, more than 50% of the athletes were unable to maintain prelockdown intensity during strength, endurance, speed, plyometric training, change of direction, and technical training. Depending on sport classification, and excluding recreational athletes, 68% to 87% of the athletes

were training ≥ 5 times per week before lockdown. The number of athletes who trained at the same frequency during lockdown was reduced by $\sim 20\%$ to 30% (Figure 1). Moreover, depending on sports, and excluding Recreational and other sports, the number of athletes who spent prelockdown training of ≥ 60 min/session (ie, $>81\%$) was greatly reduced by $\sim 30\%$ to 40% during lockdown (Figure 2). This outcome indicates that many athletes were unable and/or unwilling to reach their typical prelockdown training session duration during lockdown conditions. The observed reductions in these training variables might be partly influenced by limitations in the available training space/access and necessary equipment, with male and female athletes similarly affected (Figure 4). Such findings were observed despite relatively fewer female athletes involved in Team sports, which was one of the sport classifications most affected by lockdown. Globally, handball players reported their activities of moderate and vigorous intensity declining during lockdown, forfeiting physiological capacities and performance.³⁰ Similarly, again in handball players, reductions in weekly training days and hours due to lockdown were reported, with a greater decline among female athletes.¹¹ In the current study, Team sports athletes were much less likely to perform specific training at an intensity similar to prelockdown, especially for technical skills, speed endurance, and long endurance (Table 3). Sport-specific maneuvers including rucks, mauls, scrums, and tackling in rugby usually implemented with a partner/teammate,⁹ appeared limited. Overall, the COVID-19 lockdown provided unique and sports-specific challenges that the athletes and coaches had to counter to preserve the frequency, intensity, and duration of training. There was a substantial effort by coaches, athletes, support staff, and teams/organizations to maintain or improve performance, or some elements of the performance components, irrespective of sport and sex. Nevertheless, these modifications may lack the desired efficacy.

The scores of the knowledge and beliefs/attitudes toward training were classified *moderate*, irrespective of sports except for recreational-level and “Other”-sports athletes who were classified as *poor* for beliefs/attitudes. Endurance sports scored higher than most other sports in beliefs/attitudes, whereas athletes in Precision and Recreational sports exhibited lower training knowledge scores. The observation that the level of physical activities of Endurance athletes during lockdown can be maintained, likely reflects their abilities to self-regulate training. Endurance athletes were able to essentially replicate their prelockdown regular exercises, especially for cardiorespiratory-based training. In contrast, the scores of beliefs/attitudes in Recreational sports were at the lower end of the spectrum (Table 1), indicating a need for more upskilling related to training-related educational resources on the impacts of training or de-training; perhaps with a focus toward both health and performance. Further education and upskilling might positively influence training intensity, frequency, and volume to improve or maintain performance.^{28,29,31}

Meanwhile, the absence of competition and *normal* training seems to have affected many athletes, especially in Team and Racquet sports, with some (Team and Combat sports) revealing the importance of having teammates (and/or even opponents) present to “do more in training.”²³ Indeed, the competitive elements and positive behavioral/performance responses when training with²³ and/or competing against other athletes²³ are well known. In contrast, training alone might be unfavorable, particularly with female athletes within the present study given their increased anxious feelings and mental vulnerability during lockdown (ie, higher proportion) compared with males. The data and discussion above

emphasize the important role sporting organizations and clubs did and can play to facilitate virtual or online competitive opportunities for all athletes during lockdown and beyond. Finally, despite a disparity in sex sample size, the discrepancy is comparable to sport participation data elsewhere (eg, 40% female, 60% male in the United States)³² and the participant sex bias in scientific research per se (65% male and 35% female) within sports science and medicine.³³

Practical Applications

These sports-specific data, discussion, and recommendations should inform government and sporting organization action plans and arrangements for teams and individual athletes during lockdown-like events or situations. Most of the observed changes in athletes' training practices during the 2020 first COVID-19 lockdown were sports-specific, with trivial to small differences between male and female athletes. Maintenance of sport-specific training practices was easier in individual and less equipment-dependent sports like Endurance sports, compared with more technically demanding sports. Interactive sports such as Team sports were most dramatically impacted. Regardless of sport and sex, lockdown had negative impacts on the athletes' key training variables, including training intensity, duration, frequency, and type. Training for muscular strength, endurance, speed, plyometric, change of direction, and technical aspects had been compromised. Differences in athletes' knowledge and beliefs between sexes were trivial, and lockdown-specific educational materials (eg, sports sciences, training/performance, and motivation-related sessions/interactions), which can be facilitated by other types of assistance (eg, free-internet and financial incentives), should be considered, irrespective of sex. Utilization of new technology like virtual reality and mobile applications for training, training monitoring, and educational purposes may be useful during lockdown.² Also, we recommend the development of specific policy responses to help athletes maintain training (and competition) comparable to normal levels in future periods of lockdown. Although logistically intensive, *bubble* training or competition approaches may provide the avenue for athletes to maintain training (and compete) similarly to normal levels,^{4,34,35} but caution should be taken that prolonged *bubble* camps may be psychologically challenging for some athletes.³⁵

Conclusions

The data suggest that future lockdown-type events do not require policy or guidance to be wholly modified based on sex (although there are some nuances to consider, for example, in Recreational and Parasports). In contrast, athletes in selected sports (identified by sport classification) would likely benefit from specific training management and individualization. Most of the observed changes in the training practices of athletes during the first COVID-19 lockdown were mediated by the nature of the sports, with little to no differences for sex. Maintenance of sport-specific training practices was easier in individual and less equipment-dependent sports (eg, Endurance sports), compared with more technically demanding sports and especially Team sports. Knowledge, beliefs, and practices on training were broadly similar between male and female athletes, and across sport classifications, with the exception of recreational athletes who had a lower score (*poor* compared to *moderate*) for the training beliefs.

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