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COVID-19 lockdown: A global study investigating athletes' sport classification and sex on training practices

Original Scientific Research

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COVID-19 lockdown: A global study investigating athletes' sport classification and sex on training practices

ABSTRACT

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.[21] **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; 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 pre-lockdown, perceived training intensity was reduced by 29–41%, 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/week reduced their volume (range: 18–28%) during-lockdown. The proportion of athletes (81%) training ≥60-min/sessions reduced by 31–43% 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

INTRODUCTION

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 alongside athlete support services (e.g., sports science, sports medicine and allied health services) were at best severely restricted and at worst unavailable.[3,4] Consequently, athletes were house-bound for prolonged periods, drastically modifying their daily lives and training practices.[5,6] Additionally, sleep,[1] mental health,[7] and nutrition [8] were all impacted.

Restrictive measures including social distancing, disrupted team and contact sport athletes ability to practice sport-specific and/or contact intensive skills (e.g., 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 larger 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-min 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 (e.g. Parasport 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 bodyweight exercise, and use alternative endurance training modalities such as a cycle ergometery.[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 towards training likely impacted their self-regulation[17] 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 (i.e., handball), and the question has not been explored extensively. That said, female athletes during lockdown were more likely to experience mental health issues compared to male athletes, including depressive feelings, energy loss, and reduced motivation according to one data set.[6] Specifically, female athletes tended to be more anxious[18] and reported mood disruptions related to increased perceived stress and dysfunctional psycho-biosocial states.[19] Further, female athletes with underlying medical conditions (e.g., 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 were explored. The data will extend the initial analyses of the study focusing on overall outcomes and athlete classification[21] 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 optimise their responses to future restrictions or lockdowns.

METHODS

Participants

A sample of athletes (n = 12,526; representing 142 countries/territories across six continents) participated in the current study. Participant eligibility is described elsewhere (open-access).[21] Informed consent was provided by participants under ethical approval from: (i) University of Melbourne, Australia (HREC No. 2056955.1); (ii) Qatar University, Qatar (QU-IRB 1346-EA/20); and (iii) 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 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 days). The survey was distributed and promoted via e-mail, 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 modelling. Cronbach's alpha of 0.82 to 0.97 [21] demonstrated *good* to *excellent* reliability of the questionnaire.[22] The survey was developed initially by JAW and KC, 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; and attitude is a psychological tendency or mental predisposition, which influences how an individual behaves optimistically towards key issues.[21] Sport classification was self-report by athletes, yielding 108 different sports (and disciplines within sports). Some sports were specifically reported, e.g., 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 non-binary '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 2, Figures 2-5, and Supplementary (S) Table (S7).

Sub-groups for: (a) able-bodied; and (b) para-athletes (i.e., *Parasports*; defined as individuals requiring special assistance, or with 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 nine sport classifications and differentiated further by competitive level and recreational (i.e., *Recreational*; non-competitive participation or physical activities, usually for leisure, health or work-related) sports. Similarly, competitive sports were further sub-grouped, as follows: (i) self-dependent training in nature without or with own equipment, and those relatively longer in duration [i.e., *Endurance*; e.g., triathlon, cross country, and road cycling]; (ii) self-dependent training with technical concerns, and/or specific equipment not usually owned or easily accessible [i.e., *Power/technical*; e.g., field-events in athletics, weightlifting, and CrossFit®]; (iii) interactive or dependent on team mates [i.e., *Team*; e.g., hockey, rugby, and volleyball] or sparring/fighting [i.e., *Combat*; e.g., Muay Thai, Ju-jitsu, and wrestling]; (iv) one or more combinations of these criteria and type of sport, e.g. water-based [i.e., *Aquatic*; e.g., water polo, canoe, and sailing], racquet-based [i.e., *Racquet*; e.g., tennis, badminton, and squash], and target-based [i.e., *Precision*; e.g., archery, shooting, and bowling]; and (v) other than the seven classifications for competitive sports, or relatively competitive sports but hardly participated [i.e., *Other*; e.g., wheel gymnastic and aerial silks] (Figure 1).

***Figure 1 here please ***

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 (e.g., 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 in percentage) was used to rank the level of knowledge and beliefs/attitudes based on previously established thresholds: ≥70% as good, ≥51-<70% as moderate, and ≤50% as poor for athlete/classification comparisons.[21] The practice section comprised 11 questions, involving an array of question styles to establish training practices, including: (i) selecting one or more predefined answers; (ii) comparing related pre- to during-lockdown effects on training practices; (iii) yes or no; and (iv) sub-questions including a free-text cell to capture details.[21]

Statistical analysis

All data were coded with statistical analyses performed using SPSS v.26 (IBM, Chicago, Illinois, USA). Data are presented using a variety of appropriate descriptive statistics, including frequencies, percentages, and mean ± standard deviation. Knowledge and beliefs/attitudes scores across sex and sport classifications were compared using an independent t-test and one-way ANOVA 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; i.e., significantly higher*) or the least (*residual less than -1.96; i.e., significantly lower*) to the relationships, which corresponds to p<0.05. A McNemar-Bowker test was utilized to compare frequency and duration of training before vs. during lockdown within athletes. The odds ratio (OR), with a 95% confidence interval (CI), was used to estimate the strength of the relationship of bivariate variables by sex. Only those ORs were considered where the 95% CI did not include 0.91-1.10 range (10% change, based on 1/1.1 = 0.91 and 1*1.1 = 1.10). A difference of <10% was deemed unclear for both sport and sex comparison. A p-value of <0.05 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 1).

Table 1 here please

Table 2 here please

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 2. For both scoring scales, male and female athletes had a *moderate* level of knowledge and beliefs/attitudes. The nine questions (and aggregated answers) for knowledge towards training according to sport classification and sex are provided as Supplementary, Tables S1 and S2. The corresponding seven questions for beliefs/attitudes towards training are provided in Tables S3 and S4, respectively. Finally, the questions and answers related to knowledge and beliefs/attitudes according to sport classification and sex are shown in Tables S5 and S6, respectively.

Table 3 here please

Table 4 here please

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<0.001) 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<0.05) (Table 3). Body-weight-based exercises were most consistently performed during lockdown [67% and 64% for female and male athletes, respectively (p<0.001)]; ranging from 50% (Precision sports) to 78% (Parasports). Cardiorespiratory training was also consistently performed by most athletes, ranging from 50% in Parasports to 75% in Endurance sports. Other exercise forms (e.g., 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 to the other sports (~35%) (p<0.05). 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 to pre-lockdown (Table 3). Most athletes, 85% of females and 80% of males, reported being able to perform warm-up and stretching with the same pre-lockdown intensity during the lockdown (Table 4).

***Figure 2 here please ***

***Figure 3 here please ***

***Figure 4 here please ***

Comparisons of weekly training frequency, session duration and training intensity before, and during lockdown between sports and sex are shown in Figures 2, 3, and 4, respectively. During lockdown, the frequency of training dropped for all sport classifications ($p<0.001$). 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 ($p< 0.05$). As a whole sample, reduction in training intensity was the same for male and female athletes (~38%); with a disparity of 0-6% between males and females within different sports.

Figure 5 here please

Figure 5 shows that 44-84% 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 to strength and technical training. Male and female athletes were similarly affected (i.e., ranging from 3-6% difference between sexes, $p<0.05$) in terms of technical (access/space/necessary equipment) and cardiovascular (necessary equipment) training. Some disparity in sex distribution is evident for selected variables in different sport classifications (Figure 5).

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 (e.g., Endurance sports) were easier to maintain during lockdown than more technically demanding sports (e.g., 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, while Aquatic sports athletes were self-adjusting by amplifying their pre-lockdown 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 e.g., mental aspect (44% males vs 48% females, respectively), including inconsistencies within sports, e.g., Aquatic and Parasports. Although some sex differences were observed in overall data (0% to 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), whilst 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 (AT)] and high-intensity interval training (at or above AT).[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 pre-lockdown training intensity (36%) and plyometric training (32%). Evidently, some athletes were already in possession or were able to prepare/buy/borrow the necessary equipment (specialised 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 to others [e.g., Power/technical (78%)]. These aquatic sports athletes adopted a wide range of training modalities, including body weight-based exercises, especially females [e.g., 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 pre-lockdown 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 (e.g., for shooting) as a result of improved muscular strength and aerobic capacity.[27] It is noteworthy that within a small sample in Parasports, a higher proportion of athletes (78%) performed body-weight-based exercises, with some sex disparity evident, i.e., 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 pre-lockdown 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/week before lockdown. The number of athletes who trained at the same frequency during lockdown was reduced by ~20% to 30% (Figure 2). Moreover, depending on sports, and excluding Recreational and Other sports, the number of athletes who spent pre-lockdown training of ≥60-min/session (i.e., >81%) was greatly reduced by ~30 to 40% during lockdown (Figure 3). This outcome indicates that many athletes were unable and/or unwilling to reach their typical pre-lockdown 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 5). 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 pre-lockdown, especially for technical skills, speed endurance, and long endurance (Table 3). Sport-specific manoeuvres 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/organization 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 pre-lockdown 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 2), indicating a need for more upskilling related to training-related educational resources on the impacts of training or de-training; perhaps with a focus towards 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 behavioural/performance responses when training with[23] and/or competing against other athletes[23] are well known. In contrast, training alone might be unfavourable, particularly within female athletes within the present study given their increased anxious feelings and mental vulnerability during lockdown (i.e., higher proportion) compared to 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 (e.g., 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 were easier in individual and less equipment-dependent sports like Endurance sports, compared to 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 (e.g., sports sciences, training/performance, and motivation-related sessions/interactions), which can be facilitated by other types of assistance (e.g., 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, e.g., 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 (e.g., Endurance sports), compared to 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/attitudes.

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COMPETING INTERESTS

The authors declare that they have no competing interests

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Figures Legends

Figure 1. Flow diagram outlining sport classification process.

Figure 2. 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. %, within sex or within sports, which represent 'yes' answer relative to 'no' answer; [a], significantly higher; [b], significantly lower at $p<0.05$; Note, changes from before lockdown to during lockdown for all variables were significant ($p < 0.05$) except 'Other Female'; AQUA = aquatic, COMB = Combat, ENDU = Endurance, PARA = Parasports, PO/T = Power/technical, PREC = Precision, RACQ = Racquet, RECR = Recreational, TEAM = Team, Other = Others.

Figure 3. Training duration of ≥60-min per session based on sport classification and sex before and during lockdown (n = 12,241).

Ordered from smallest to largest reductions. %, within sports or within sex, which represent 'yes' answer relative to 'no' answer; [a], significantly higher; [b], significantly lower at $p<0.05$; Note, changes from before lockdown to during lockdown for all variables were significant ($p < 0.05$); AQUA = aquatic, COMB = Combat, ENDU = Endurance, PARA = Parasports, PO/T = Power/technical, PREC = Precision, RACQ = Racquet, RECR = Recreational, TEAM = Team, Other = Others.

Figure 4. Training intensity during lockdown session based on sport classification and sex.

Question: Do/did you maintain your pre-lockdown 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 = aquatic, COMB = Combat, ENDU = Endurance, PARA = Parasports, PO/T = Power/technical, PREC = Precision, RACQ = Racquet, RECR = Recreational, TEAM = Team, Other = Others; O = overall data, M = male, F = female; note, all comparisons between male and female athletes were significant at $p<0.001$.

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 dataset, 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.

Figure 5. 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:

%, within sex or within sports, which represent 'yes' answer relative to 'no' answer; [a], significantly higher; [b], significantly lower at $p<0.05$; *, significantly higher than male; AQUA = aquatic, COMB = Combat, ENDU = Endurance, PARA = Parasports, PO/T = Power/technical, PREC = Precision, RACQ = Racquet, RECR = Recreational, TEAM = Team, Other = Others.

Table 1. Demographic characteristics of participants by sport classification and sex. Between-sports proportion entails a comparison between all sports within a specific sex only.

	Total (n = 12526)	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: 31 athletes indicated a non-binary ‘sex’ or did not indicate ‘sex’ (male/female) and were excluded for sex comparison

Table 2. 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		**BA**	
	Knowledge	**BA**	**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				

Data are mean ± SD; Scoring threshold: ≥70% = good, >50-<70% = moderate, and ≤50% = poor; BA = beliefs/attitudes.

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 & 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
Note: M/d = Maintain or develop										
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)										
Body-weight 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
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 pre-lockdown)? (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]

For all questions, athletes were allowed to select multiple answers; %, within sport classification, represent 'yes' answer, relative to 'no' answer; *, significant relationship with sport classification; [a], significantly higher; [b], significantly lower at $p<0.05$; AQUA = aquatic, COMB = Combat, ENDU = Endurance, PARA = Parasports, PO/T = Power/technical, PREC = Precision, RACQ = Racquet, RECR = Recreational, TEAM = Team, Other = Others. Note: this Table is in conjunction with Table S7 (supplementary) that include details of male and female athletes; answer's selections are shortened, long version can be seen in Table 4.

Table 4. Practices during COVID-19 lockdown by athletes based on sex.

	Male %	Female %	OR (95% CI)*
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)			
Body-weight 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 pre-lockdown)? (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 (e.g., 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)

For all questions, athletes were allowed to select multiple answers; valid % computed excluding missing values, within sex, represent ‘yes’ answer, relative to ‘no’ answer. * Ratio of participant knowledge among males using “females” as reference; bolded, 95% CI outside of 0.91-1.10 range (10% change or ‘clear’ difference);

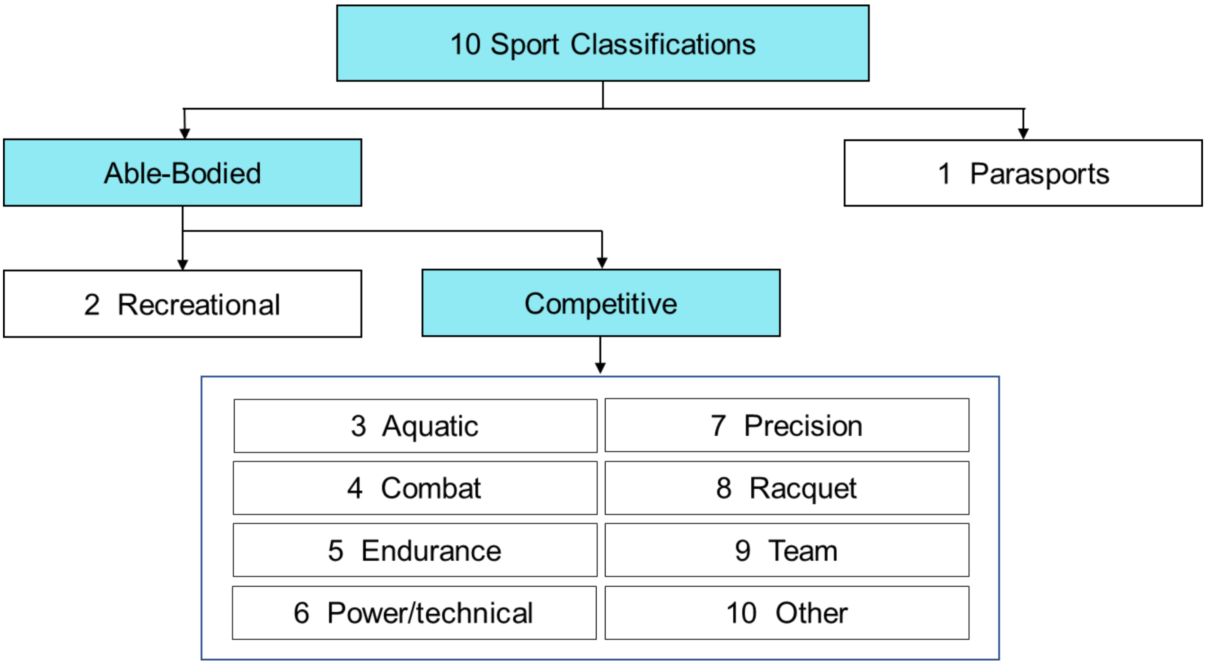

Figure 1. Flow diagram outlining sport classification process.

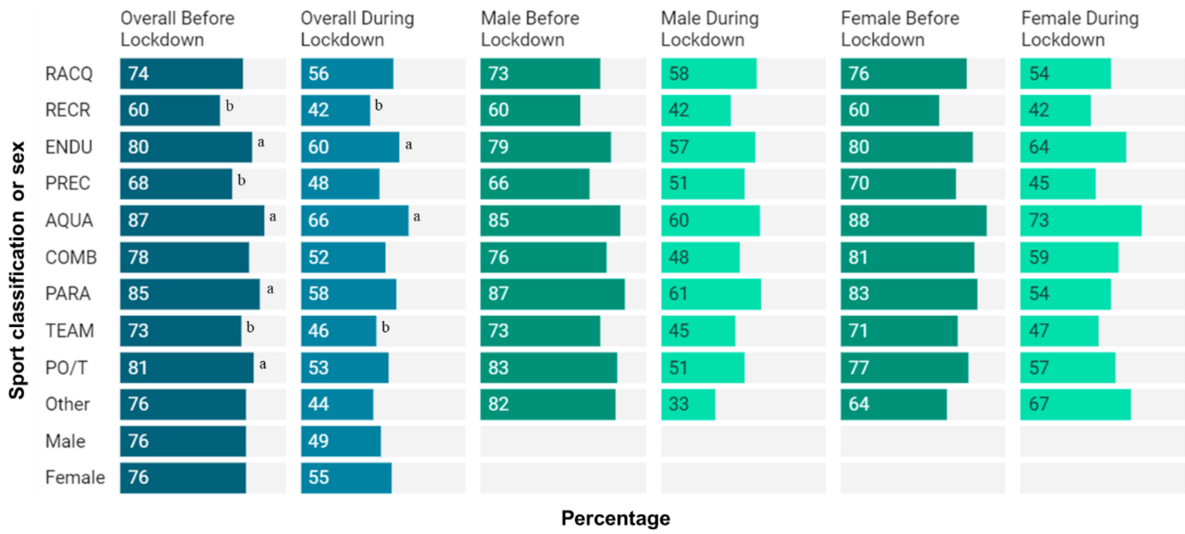

Figure 2. Training frequency of ≥5 times per week based on sport classification and sex before and during lockdown (n = 11,626).

Ordered from smallest to largest reductions. %, within sex or within sports, which represent 'yes' answer relative to 'no' answer; [a], significantly higher; [b], significantly lower at $p<0.05$; Note, changes from before lockdown to during lockdown for all variables were significant ($p < 0.05$) except 'Other Female'; AQUA = aquatic, COMB = Combat, ENDU = Endurance, PARA = Parasports, PO/T = Power/technical, PREC = Precision, RACQ = Racquet, RECR = Recreational, TEAM = Team, Other = Others.

Figure 3. Training duration of ≥60-min per session based on sport classification and sex before and during lockdown (n = 12,241).

Ordered from smallest to largest reductions. %, within sports or within sex, which represent 'yes' answer relative to 'no' answer; [a], significantly higher; [b], significantly lower at $p<0.05$; Note, changes from before lockdown to during lockdown for all variables were significant ($p < 0.05$); AQUA = aquatic, COMB = Combat, ENDU = Endurance, PARA = Parasports, PO/T = Power/technical, PREC = Precision, RACQ = Racquet, RECR = Recreational, TEAM = Team, Other = Others.

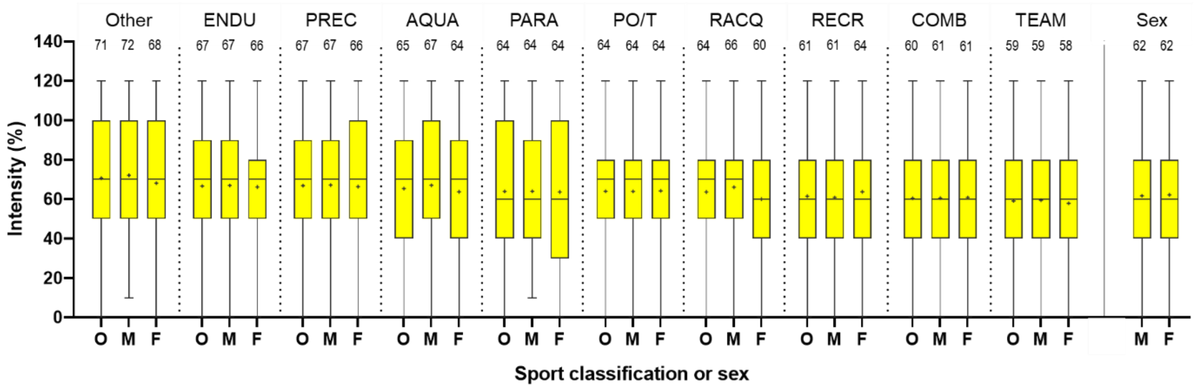

Figure 4. Training intensity during lockdown session based on sport classification and sex.

Question: Do/did you maintain your pre-lockdown 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 = aquatic, COMB = Combat, ENDU = Endurance, PARA = Parasports, PO/T = Power/technical, PREC = Precision, RACQ = Racquet, RECR = Recreational, TEAM = Team, Other = Others; O = overall data, M = male, F = female; note, all comparisons between male and female athletes were significant at $p<0.001$ (0-6% depending on sports).

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 dataset, 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.

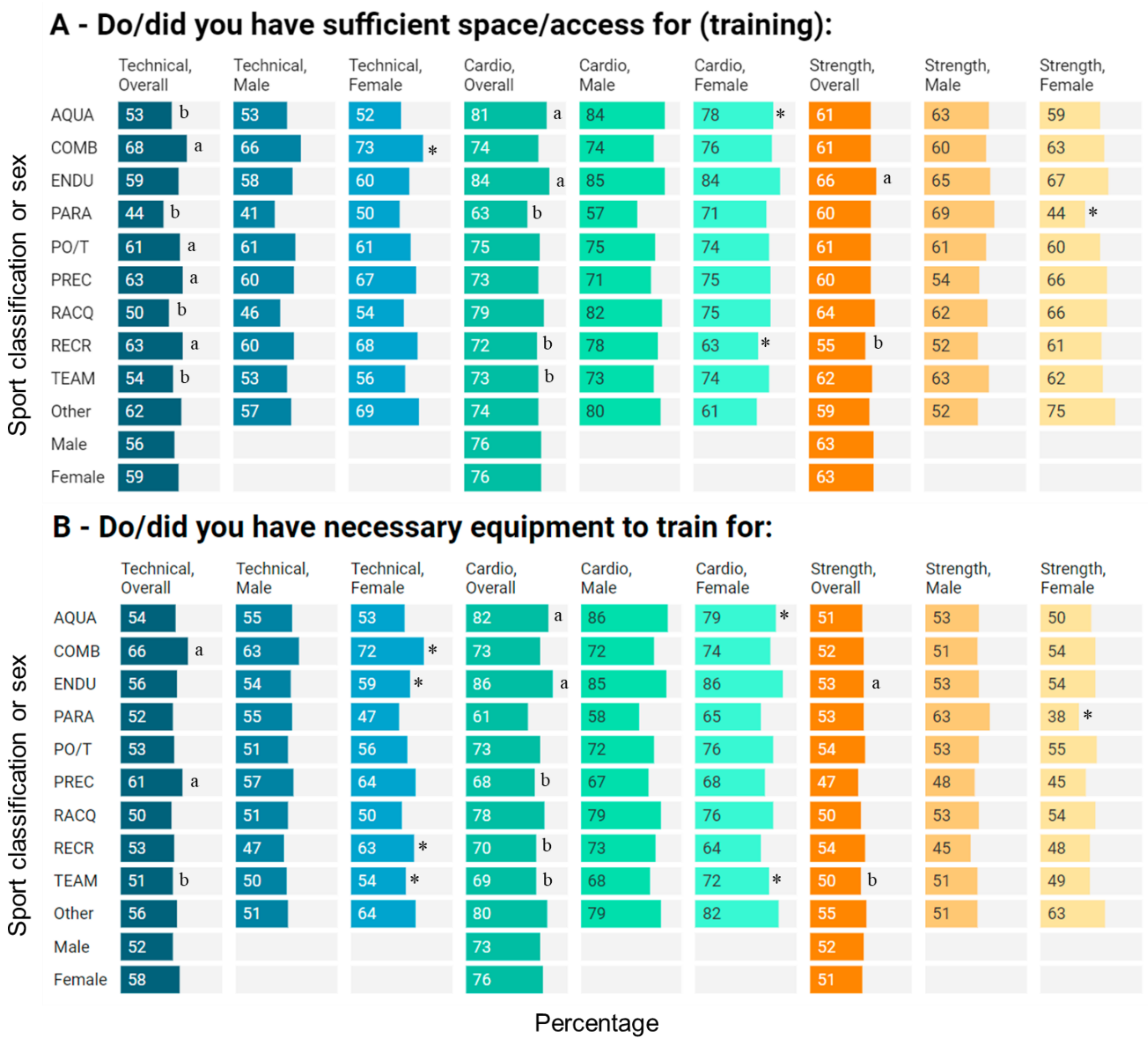

Figure 5. Reported practices for space/access and equipment to training based on sport classification and sex (n = 11,451).

Question: Do/did you have **(A)** sufficient space/access, and **(B)** necessary equipment to train for:

%, within sex or within sports, which represent 'yes' answer relative to 'no' answer; [a], significantly higher; [b], significantly lower at $p<0.05$; *, significantly higher than male; AQUA = aquatic, COMB = Combat, ENDU = Endurance, PARA = Parasports, PO/T = Power/technical, PREC = Precision, RACQ = Racquet, RECR = Recreational, TEAM = Team, Other = Others.