**Washif, Jad Adrian, Sandbakk, Oyvind, Seiler, Stephen, Haugen, Thomas, Farooq, Abdulaziz, Quarrie, Ken, van Rensburg, Dina C. Janse, Krug, Isabel, Verhagen, Evert, Wong, Del P., Mujika, Inigo, Cortis, Cristina, Haddad, Monoem, Ahmadian, Omid, Al Jufaili, Mahmood, Al-Horani, Ramzi A., Al-Mohannadi, Abdulla Saeed, Aloui, Asma, Ammar, Achraf, Arifi, Fitim, Aziz, Abdul Rashid, Batuev, Mikhail, Beaven, Christopher Martyn, Beneke, Ralph, Bici, Arben, Bishnoi, Pallawi, Bogwasi, Lone, Bok, Daniel, Boukhris, Omar, Boullosa, Daniel, Bragazzi, Nicola, Brito, Joao, Cartagena, Roxana Paola Palacios, Chaouachi, Anis, Cheung, Stephen S., Chtourou, Hamdi, Cosma, Germina, Debevec, Tadej, DeLang, Matthew D., Dellal, Alexandre, Donmez, Gurhan, Driss, Tarak, Duque, Juan David Pena, Eirale, Cristiano, Elloumi, Mohamed, Foster, Carl, Franchini, Emerson, Fusco, Andrea, Galy, Olivier, Gastin, Paul B., Gill, Nicholas, Girard, Olivier, Gregov, Cvita, Halson, Shona, Hammouda, Omar, Hanzlikova, Ivana, Hassanmirzaei, Bahar, Hebert-Losier, Kim, Helu, Hussein Munoz, Herrera-Valenzuela, Tomas, Hettinga, Florentina J., Holtzhausen, Louis, Hue, Olivier, Dello Iacono, Antonio, Ihalainen, Johanna K., James, Carl, Joseph, Saju, Kamoun, Karim, Khaled, Mehdi, Khalladi, Karim, Kim, Kwang Joon, Kok, Lian-Yee, MacMillan, Lewis, Mataruna-Dos-Santos, Leonardo Jose, Matsunaga, Ryo, Memishi, Shpresa, Millet, Gregoire P., Moussa-Chamari, Imen, Musa, Danladi Ibrahim, Hoang Minh Thuan Nguyen, , Nikolaidis, Pantelis T., Owen, Adam, Padulo, Johnny, Pagaduan, Jeffrey Cabayan, Perera, Nirmala Panagodage, Perez-Gomez, Jorge, Pillay, Lervasen, Popa, Arporn, Pudasaini, Avishkar, Rabbani, Alizera, Rahayu, Tandiyo, Romdhani, Mohamed, Salamh, Paul, Sarkar, Abu-Sufian, Schillinger, Andy,**

# Northumbria Research Link

International Journal of Sports Physiology and Performance

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

Original Scientific Research

Jad Adrian Washif[1,*], Øyvind Sandbakk[2], Stephen Seiler[3], Thomas Haugen[4], Abdulaziz Farooq[5], Ken Quarrie[6], Dina C. Janse van Rensburg[7,8], Isabel Krug[9], Evert Verhagen[10], Del P. Wong[11], Iñigo Mujika[12,13], Cristina Cortis[14], Monoem Haddad[15], Omid Ahmadian[16], Mahmood Al Jufaili[17], Ramzi A. Al-Horani[18], Abdulla Saeed Al-Mohannadi[19], Asma Aloui[20,21], Achraf Ammar[22,23], Fitim Arifi[24,25], Abdul Rashid Aziz[26], Mikhail Batuev[27], Christopher Martyn Beaven[28], Ralph Beneke[29], Arben Bici[30], Pallawi Bishnoi[31], Lone Bogwasi[32,33], Daniel Bok[34], Omar Boukhris[20,21], Daniel Boullosa[35,36], Nicola Bragazzi[37], Joao Brito[38], Roxana Paola Palacios Cartagena[39], Anis Chaouachi[40,41], Stephen S. Cheung[42], Hamdi Chtourou[20,21], Germina Cosma[43], Tadej Debevec[44,45], Matthew D. DeLang[46], Alexandre Dellal[47,48], Gürhan Dönmez[49], Tarak Driss[50], Juan David Peña Duque[51], Cristiano Eirale[52], Mohamed Elloumi[53], Carl Foster[54], Emerson Franchini[55], Andrea Fusco[14], Olivier Galy[56], Paul B. Gastin[57], Nicholas Gill[2,28], Olivier Girard[58], Cvita Gregov[34], Shona Halson[59], Omar Hammouda[60,61], Ivana Hanzlíková[28], Bahar Hassanmirzaei[62,63], Kim Hébert-Losier[28], Hussein Muñoz Helú[64], Tomás Herrera-Valenzuela[65,66], Florentina J. Hettinga[27], Louis Holtzhausen[5,7,67,68], Olivier Hue[69], Antonio Dello Iacono[70], Johanna Ihalainen[71], Carl James[1], Saju Joseph[72], Karim Kamoun[40], Mehdi Khaled[73], Karim Khalladi[5], Kwang Joon Kim[74], Lian-Yee Kok[75], Lewis MacMillan[76], Leonardo Jose Mataruna-Dos-Santos[77,78,79], Ryo Matsunaga[80,81], Shpresa Memishi[82], Grégoire P. Millet[83], Imen Moussa-Chamari[15], Danladi Ibrahim Musa[84], Hoang Minh Thuan Nguyen[85], Pantelis T. Nikolaidis[86], Adam Owen[87,88], Johnny Padulo[89], Jeffrey Cabayan Pagaduan[90], Nirmala Panagodage Perera[91,92,93], Jorge Pérez-Gómez[94], Lervasen Pillay[7,95], Arporn Popa[96], Avishkar Pudasaini[97], Alizera Rabbani[98], Tandiyo Rahayu[99], Mohamed Romdhani[20], Paul Salamh[100], Abu-Sufian Sarkar[101], Andy Schillinger[102], Heny Setyawati[99], Navina Shrestha[97,103], Fatona Suraya[99], Montassar Tabben[5], Khaled Trabelsi[21,104], Axel Urhausen[105,106,107], Maarit Valtonen[108], Johanna Weber[109,110], Rodney Whiteley[5,111], Adel Zrane[112,113,114], Yacine Zerguini[115,116], Piotr Zmijewski[117], Helmi Ben Saad[118,119], David B. Pyne[120,#], Lee Taylor[121,122,123,#], Karim Chamari[5,#]

## Author information

Jad Adrian Washif[1] (**corresponding author*)
Email: jad@isn.gov.my
[1] Sports Performance Division, Institut Sukan Negara Malaysia (National Sports Institute of Malaysia), 57000 Kuala Lumpur, Malaysia
Tel: 03-8991 4400
https://orcid.org/0000-0001-8543-4489

Øyvind Sandbakk[2]
[2] Centre for Elite Sports Research, Department of Neuromedicine and Movement Science, Norwegian, University of Science and Technology, Trondheim, Norway
https://orcid.org/0000-0002-9014-5152

Stephen Seiler[3]
[3] Department of Sports Science and Physical Education, University of Agder, Kristiansand, Norway
https://orcid.org/0000-0001-8024-5232

Thomas Haugen[4]
[4] School of Health Sciences, Kristiania University College, Norway

Abdulaziz Farooq[5]
[5] Aspetar, Orthopaedic and Sports Medicine Hospital, FIFA Medical Centre of Excellence, Doha, Qatar
https://orcid.org/0000-0002-9162-4948

Ken Quarrie[6]
[6] New Zealand Rugby, Wellington, New Zealand

Dina C. Janse van Rensburg[7,8]
[7] Section Sports Medicine, Faculty of Health Sciences, University of Pretoria, Pretoria, South Africa
[8] Medical Board Member, World Netball, Manchester, United Kingdom
https://orcid.org/0000-0003-1058-6992

Isabel Krug[9]
[9] Melbourne School of Psychological Sciences, The University of Melbourne, Melbourne, VIC, Australia
https://orcid.org/0000-0002-5275-3595

Evert Verhagen[10]
[10] Department of Public and Occupational Health, Amsterdam Collaboration on Health & Safety in Sports, Amsterdam Movement Sciences, Amsterdam UMC, Vrije Universiteit Amsterdam, Amsterdam, The Netherlands
https://orcid.org/0000-0001-9227-8234

Del P. Wong[11]
[11] School of Nursing and Health Studies, Hong Kong Metropolitan University, Ho Man Tin, Hong Kong
https://orcid.org/0000-0002-8481-3417

Iñigo Mujika[12,13]
[12] Department of Physiology, Faculty of Medicine and Nursing, University of the Basque Country, Leioa, Basque Country
[13] Exercise Science Laboratory, School of Kinesiology, Faculty of Medicine, Universidad Finis Terrae, Santiago, Chile
https://orcid.org/0000-0002-8143-9132

Cristina Cortis[14]
[14] Department of Human Sciences, Society and Health, University of Cassino and Lazio Meridionale, Cassino, Italy
https://orcid.org/0000-0001-9643-5532

Monoem Haddad[15]
[15] Physical Education Department, College of Education, Qatar University, Doha, Qatar
https://orcid.org/0000-0001-5989-1627

Omid Ahmadian[16]
[16] Medical committee of Tehran Football Association, Tehran, Iran

Mahmood Al Jufaili[17]
[17] Emergency Medicine Department, Sultan Qaboos University Hospital, Alkhoudh, Oman
https://orcid.org/0000-0002-6250-0321

Ramzi A. Al-Horani[18]
[18] Department of exercise science, Yarmouk University, Irbid, Jordan
https://orcid.org/0000-0002-6915-816X

Abdulla Saeed Al-Mohannadi[19]
[19] World Innovation Summit for Health (WISH), Qatar Foundation, Doha, Qatar
https://orcid.org/0000-0002-8342-8576

Asma Aloui[20,21]
[20] Physical Activity, Sport & Health Research Unit (UR18JS01), National Sport Observatory, Tunis, Tunisia
[21] High Institute of Sport and Physical Education, University of Gafsa, Gasfa, Tunisia
https://orcid.org/0000-0001-5054-1540

Achraf Ammar[22,23]
[22] Institute of Sport Sciences, Otto-von-Guericke University, 39104 Magdeburg, Germany
[23] Interdisciplinary Laboratory in Neurosciences, Physiology and Psychology: Physical Activity, Health and Learning (LINP2), UFR STAPS, UPL, Paris Nanterre University, Nanterre, France
https://orcid.org/0000-0003-0347-8053

Fitim Arifi[24,25]
[24] College Universi, Physical Culture, Sports and Recreation, Prishtina, Kosovo
[25] University of Tetova, Faculty of Physical Education and Sport, Tetovo, North Macedonia
https://orcid.org/0000-0002-9710-314X

Abdul Rashid Aziz[26]
[26] Sport Science and Sport Medicine, Singapore Sport Institute, Sport Singapore, Singapore, Singapore
https://orcid.org/0000-0002-7727-7484

Mikhail Batuev[27]
[27] Department of Sport, Exercise and Rehabilitation, Northumbria University, Newcastle upon Tyne, United Kingdom
https://orcid.org/0000-0001-9618-1907

Christopher Martyn Beaven[28]
[28] Division of Health, Engineering, Computing and Science, Te Huataki Waiora School of Health, University of Waikato, Tauranga, New Zealand

https://orcid.org/0000-0003-2900-7460

Ralph Beneke[29]
[29] Division of Medicine, Training and Health, Institute of Sport Science and Motology, Philipps University Marburg, Marburg, Germany

Arben Bici[30]
[30] Institute of Sport Research, Applied Motion Department, Sports University of Tirana, Tirana, Albania

Pallawi Bishnoi[31]
[31] Physiotherapy Department, Minerva Punjab Academy and Football Club, Mohali, Punjab, India

Lone Bogwasi[32,33]
[32] Department of Orthopedics, Nyangabgwe Hospital, Francistown, Botswana
[33] Botswana Football Association Medical committee, Gaborone, Botswana

Daniel Bok[34]
[34] Faculty of Kinesiology, University of Zagreb, Zagreb, Croatia
http://orcid.org/0000-0003-4847-9818

Omar Boukhris[20,21]
[20] Physical Activity, Sport & Health Research Unit (UR18JS01), National Sport Observatory, Tunis, Tunisia
[21] High Institute of Sport and Physical Education, University of Sfax, Sfax, Tunisia
https://orcid.org/0000-0002-2861-0164

Daniel Boullosa[35,36]
[35] INISA, Federal University of Mato Grosso do Sul, Campo Grande, Brazil
[36] Sport and Exercise Science, James Cook University, Townsville, QLD, Australia
https://orcid.org/0000-0002-8477-127X

Nicola Bragazzi[37]
[37] Laboratory for Industrial and Applied Mathematics (LIAM), Department of Mathematics and Statistics, York University, Toronto, ON M3J 1P3, Canada
https://orcid.org/0000-0001-8409-868X

Joao Brito[38]
[38] Portugal Football School, Portuguese Football Federation, Oeiras, Portugal
https://orcid.org/0000-0003-1301-1078

Roxana Paola Palacios Cartagena[39]
[39] Facultad de Ciencias del Deporte, Universidad de Extremadura, Cáceres, Spain

Anis Chaouachi[40,41]
[40] Tunisian Research Laboratory, Sport Performance Optimisation, National Center of Medicine and Science in Sports (CNMSS), Tunis, Tunisia
[41] Sports Performance Research Institute New Zealand, AUT University, Auckland, New Zealand

https://orcid.org/0000-0001-9178-7678

Stephen S. Cheung[42]
[42] Department of Kinesiology, Brock University, St. Catharines, ON, Canada
https://orcid.org/0000-0002-6149-4978

Hamdi Chtourou[20,21]
[20] Physical Activity, Sport & Health Research Unit (UR18JS01), National Sport Observatory, Tunis, Tunisia
[21] High Institute of Sport and Physical Education, University of Sfax, Sfax, Tunisia
https://orcid.org/0000-0002-5482-9151

Germina Cosma[43]
[43] University of Craiova, Faculty of Physical Education and Sport, Craiova, Romania
https://orcid.org/0000-0002-4636-8041

Tadej Debevec[44,45]
[44] Faculty of Sport, University of Ljubljana, Slovenia
[45] Department of Automation, Biocybernetics and Robotics, Jozef Stefan Institute, Ljubljana, Slovenia
https://orcid.org/0000-0001-7053-3978

Matthew D. DeLang[46]
[46] Right to Dream Academy, Old Akrade, Ghana

Alexandre Dellal[47,48]
[47] Sport Science and Research Department, Centre Orthopédique Santy, FIFA Medical Centre of Excellence, Lyon, France
[48] Laboratoire Interuniversitaire de Biologie de la Motricité (LIBM EA), Claude Bernard University (Lyon 1), Lyon, France

Gürhan Dönmez[49]
[49] Department of Sports Medicine, Hacettepe University, Ankara, Turkey
https://orcid.org/0000-0001-6379-669X

Tarak Driss[50]
[50] Interdisciplinary Laboratory in Neurosciences, Physiology and Psychology: Physical activity, Health and learning (LINP2), UFR STAPS, UPL, Paris Nanterre University, Nanterre, France
https://orcid.org/0000-0001-6109-7393

Juan David Peña Duque[51]
[51] Al Hilal Football Club, Riyadh, Saudi Arabia

Cristiano Eirale[52]
[52] Paris Saint Germain FC, Paris, France

Mohamed Elloumi[53]
[53] Prince Sultan University, Health and Physical Education Department, Riyadh, Kingdom of Saudi Arabia

https://orcid.org/0000-0003-3751-2125

Carl Foster[54]
[54] Department of Exercise and Sport Science, University of Wisconsin-La Crosse, La Crosse, Wisconsin, WI, USA

Emerson Franchini[55]
[55] Sport Department, School of Physical Education and Sport, University of São Paulo, São Paulo, Brazil
https://orcid.org/0000-0002-0769-8398

Andrea Fusco[14]
[14] Department of Human Sciences, Society and Health, University of Cassino and Lazio Meridionale, Italy
https://orcid.org/0000-0002-9090-4454

Olivier Galy[56]
[56] Interdisciplinary Laboratory for Research in Education, EA 7483, University of New Caledonia, Avenue James Cook, 98800 Nouméa, New Caledonia
https://orcid.org/0000-0002-4631-959X

Paul B. Gastin[57]
[57] Sport and Exercise Science, School of Allied Health, Human Services and Sport, La Trobe University, Melbourne, VIC, Australia
https://orcid.org/0000-0003-2320-7875

Nicholas Gill[6,28]
[6] New Zealand Rugby, Wellington, New Zealand
[28] Division of Health, Engineering, Computing and Science, Te Huataki Waiora School of Health, University of Waikato, Tauranga, New Zealand

Olivier Girard[58]
[58] School of Human Science (Exercise and Sport Science), The University of Western Australia, Perth, WA, Australia
https://orcid.org/0000-0002-4797-182X

Cvita Gregov[34]
[34] Faculty of Kinesiology, University of Zagreb, Zagreb, Croatia

Shona Halson[59]
[59] School of Behavioural and Health Sciences, McAuley at Banyo, Australian Catholic University, Brisbane, QLD, Australia
https://orcid.org/0000-0002-1047-3878

Omar Hammouda[60,61]
[60] Interdisciplinary Laboratory in Neurosciences, Physiology and Psychology: Physical Activity, Health and learning (LINP2), UPL, UFR STAPS, Paris Nanterre University, Nanterre, France
[61] Research Laboratory, Molecular Bases of Human Pathology, LR19ES13, Faculty of Medicine, University of Sfax, Sfax, Tunisia

Ivana Hanzlíková[28]
[28] Division of Health, Engineering, Computing and Science, Te Huataki Waiora School of Health, University of Waikato, Tauranga, New Zealand
https://orcid.org/0000-0002-2259-9312

Bahar Hassanmirzaei[62,63]
[62] Sports Medicine Research Center, Neuroscience Institute, Tehran University of Medical Sciences, Tehran, Iran
[63] Iran Football Medical Assessments and Rehabilitation Center - IFMARC, Tehran, Iran
https://orcid.org/0000-0003-2961-7955

Kim Hébert-Losier[28]
[28] Division of Health, Engineering, Computing and Science, Te Huataki Waiora School of Health, University of Waikato, Tauranga, New Zealand
https://orcid.org/0000-0003-1087-4986

Hussein Muñoz Helú[64]
[64] Department of Economic-Administrative Sciences, Universidad Autónoma de Occidente, Los Mochis, Sinaloa, México
https://orcid.org/0000-0001-9094-5566

Tomás Herrera-Valenzuela[65,66]
[65] Department of Sport Science and Health, Universidad Santo Tomás, Chile
[66] University of Santiago of Chile (USACH), Sciences of physical activity, sports and health school, Chile
https://orcid.org/0000-0002-5219-5896

Florentina J. Hettinga[27]
[27] Department of Sport, Exercise and Rehabilitation, Northumbria University, Newcastle upon Tyne, United Kingdom
https://orcid.org/0000-0002-7027-8126

Louis Holtzhausen[5,7,67,68]
[5] Aspetar, Orthopaedic and Sports Medicine Hospital, FIFA Medical Centre of Excellence, Doha, Qatar
[7] Section Sports Medicine, Faculty of Health Sciences, University of Pretoria, Pretoria, South Africa
[67] Weil-Cornell Medical College in Qatar, Doha, Qatar
[68] Department of Exercise and Sports Science, University of the Free State, Bloemfontein, South Africa
https://orcid.org/0000-0002-4002-8679

Olivier Hue[69]
[69] Laboratoire ACTES, UFR-STAPS, Université des Antilles, Pointe à Pitre, France

Antonio Dello Iacono[70]
[70]School of Health and Life Sciences, University of the West of Scotland, Hamilton, United Kingdom
https://orcid.org/0000-0003-0204-0957

Johanna K. Ihalainen[71]
[71] Biology of Physical Activity, Faculty of Sport and Health Sciences, University of Jyväskylä, Jyväskylä, Finland
https://orcid.org/0000-0001-9428-4689

Carl James[1]
[1] Sports Performance Division, Institut Sukan Negara Malaysia (National Sports Institute of Malaysia), 57000 Kuala Lumpur, Malaysia
https://orcid.org/0000-0003-2099-5343

Saju Joseph[72]
[72] High Performance Director, Sports Authority of India, Bangalore, India

Karim Kamoun[40]
[40] Tunisian Research Laboratory, Sport Performance Optimization, National Center of Medicine Science in Sport (CNMSS), Tunis, Tunisia

Mehdi Khaled[73]
[73] SEHA, Singapore, Singapore
https://orcid.org/0000-0003-0200-6732

Karim Khalladi[5]
[5] Aspetar, Orthopaedic and Sports Medicine Hospital, FIFA Medical Centre of Excellence, Doha, Qatar
https://orcid.org/0000-0002-1522-4598

Kwang Joon Kim[74]
[74]Department of Internal Medicine,Yonsei University College of Medicine, Seoul, South Korea

Lian-Yee Kok[75]
[75] Department of Sport Science, Tunku Abdul Rahman University College, Kuala Lumpur, Malaysia

Lewis MacMillan[76]
[76] Sport Science Department, Fulham Football Club, Fulham, London, United Kingdom
https://orcid.org/0000-0002-9043-1378

Leonardo Jose Mataruna-Dos-Santos[77,78,79]
[77] Centre for Trust, Peace and Social Relation, Coventry University, Coventry, United Kingdom
[78] Department of Sport Management, Faculty of Management, Canadian University of Dubai, Dubai, United Arab Emirates
[79] Programa Avancado de Cultura Contemporanea, Universidade Federal do Rio de Janeiro, Rio de Janeiro, Brazil
https://orcid.org/0000-0001-9456-5974

Ryo Matsunaga[80,81]
[80] Antlers Sports Clinic, Japan
[81] Department of Orthopedic Surgery, Tokyo Medical University, Ibaraki, Japan

Shpresa Memishi[82]
[82] Faculty of Physical Education, University of Tetovo, Tetovo, North Macedonia

Grégoire P. Millet[83]
[83] Institute of Sport Sciences, University of Lausanne, Lausanne, Switzerland
http://orcid.org/0000-0001-8081-4423

Imen Moussa-Chamari[15]
[15] Physical Education Department, College of Education, Qatar University, Doha, Qatar
https://orcid.org/0000-0002-7849-9687

Danladi Ibrahim Musa[84]
[84] Department of Human Kinetics and Health Education, Kogi State University, Anyigba, Nigeria
https://orcid.org/0000-0001-6310-1149

Hoàng Minh Thuận Nguyễn[85]
[85]University of Sport Ho Chi Minh City, Ho Chi Minh, Vietnam

Pantelis T. Nikolaidis[86]
[86] School of Health and Caring Sciences, University of West Attica, Attica, Greece
https://orcid.org/0000-0001-8030-7122

Adam Owen[87,88]
[87] University Claude Bernard Lyon 1, Lyon, France
[88] Seattle Sounders Football Club, Seattle, WA, USA

Johnny Padulo[89]
[89] Department of Biomedical Sciences for Health, Università degli Studi di Milano, Milan, Italy
https://orcid.org/0000-0002-4254-3105

Jeffrey Cabayan Pagaduan[90]
[90] School of Health Sciences, College of Health and Medicine, University of Tasmania, Launceston, TAS, Australia

Nirmala Panagodage Perera[91,92,93]
[91] Sports Medicine, Australian Institute of Sport, Bruce ACT, Australia
[92] University of Canberra Research Institute for Sport and Exercise (UCRISE), University of Canberra, Bruce ACT, Australia
[93] Nuffield Department of Orthopaedics, Rheumatology and Musculoskeletal Sciences, University of Oxford, Oxford, United Kingdom
https://orcid.org/0000-0001-6110-8945

Jorge Pérez-Gómez[94]
[94] Health, Economy, Motricity and Education (HEME) Research Group, Faculty of Sport Sciences, University of Extremadura, Cáceres, Spain
https://orcid.org/0000-0002-4054-9132

Lervasen Pillay[7,95]

[7] Section Sports Medicine, Faculty of Health Sciences, University of Pretoria, Pretoria, South Africa
[95] University of Witwatersrand, Wits institute for Sports Health, Johannesburg, South Africa
https://orcid.org/0000-0002-8353-3376

Arporn Popa[96]
[96] Health and Sport Science Department, Educational Faculty, Mahasarakham University, Mahasarakham, Thailand

Avishkar Pudasaini[97]
[97] Medical Department, All Nepal Football Association (ANFA), Lalitpur, Nepal

Alireza Rabbani[98]
[98] Department of Exercise Physiology, College of Sport Sciences, University of Isfahan, Isfahan, Iran
https://orcid.org/0000-0002-1500-0447

Tandiyo Rahayu[99]
[99] Faculty of Sport Science, Universitas Negeri Semarang, Semarang, Indonesia
https://orcid.org/0000-0002-8690-6377

Mohamed Romdhani[20]
[20] Physical Activity, Sport & Health Research Unit (UR18JS01), National Sport Observatory, Tunis, Tunisia
https://orcid.org/0000-0002-1715-1863

Paul Salamh[100]
[100] Krannert School of Physical Therapy, University of Indianapolis, Indianapolis, IN, USA

Abu-Sufian Sarkar[101]
[101] Bashundhara Kings, Nilphamari, Bangladesh

Andy Schillinger[102]
[102] Miskawaan Health Group, Bangkok, Thailand

Heny Setyawati[99]
[99] Faculty of Sport Science, Universitas Negeri Semarang, Semarang, Indonesia
https://orcid.org/0000-0001-9824-8626

Navina Shrestha[97,103]
[97] Medical Department, All Nepal Football Association (ANFA), Lalitpur, Nepal
[103] Physiotherapy Department, BP Eyes Foundation CHEERS Hospital, Bhaktapur, Nepal

Fatona Suraya[99]
[99] Faculty of Sport Science, Universitas Negeri Semarang, Semarang, Indonesia
https://orcid.org/0000-0001-9099-2127

Montassar Tabben[5]
[5] Aspetar, Orthopaedic and Sports Medicine Hospital, FIFA Medical Centre of Excellence, Doha, Qatar

Khaled Trabelsi[21,104]
[21] High Institute of Sport and Physical Education, University of Sfax, Sfax, Tunisia
[105] Research Laboratory: Education, Motricity, Sport and Health, EM2S, LR19JS01, University of Sfax, Sfax, Tunisia
https://orcid.org/0000-0003-2623-9557

Axel Urhausen[105,106,107]
[105] Sports Clinic, Centre Hospitalier de Luxembourg, Clinique d‘Eich, Luxembourg, Luxembourg
[106] Luxembourg Institute of Research in Orthopedics, Sports Medicine and Science, Luxembourg, Luxembourg
[107] Human Motion, Orthopedics, Sports Medicine and Digital Methods, Luxembourg Institute of Health, Luxembourg, Luxembourg

Maarit Valtonen[108]
[108] Research Institute for Olympic Sports, Jyvaskyla, Finland
https://orcid.org/0000-0001-8883-2255

Johanna Weber[109,110]
[109] Institute for Sports Science, CAU of Kiel, Kiel, Germany
[110] Neurocognition and Action, University of Bielefeld, Bielefeld, Germany
https://orcid.org/0000-0002-3735-4254

Rodney Whiteley[5,111]
[5] Aspetar, Orthopaedic and Sports Medicine Hospital, FIFA Medical Centre of Excellence, Doha, Qatar
[111] University of Queensland, Brisbane, QLD, Australia
https://orcid.org/0000-0002-1452-6228

Adel Zrane[112,113,114]
[112] Department of Physiology and Lung Function Testing, Faculty of Medicine of Sousse, University of Sousse, Sousse, Tunisia
[113] Faculty of Sciences of Bizerte, University of Carthage, Bizerte, Tunisia
[114] High Institute of Sports, Ksar Said, Tunis, Tunisia

Yacine Zerguini[115,116]
[115] FIFA Medical Centre of Excellence Algiers, Algeria
[116] Medical Committee, Confederation of African Football, Egypt

Piotr Zmijewski[117]
[117] Jozef Pilsudski University of Physical Education in Warsaw, Warsaw, Poland
https://orcid.org/0000-0002-5570-9573

Helmi Ben Saad[118,119]
[118] Laboratoire de Recherche "Insuffisance Cardiaque" (LR12SP09), Hôpital Farhat HACHED, Université de Sousse, Sousse, Tunisie
[119] Laboratoire de Physiologie, Faculté de Médicine de Sousse, Université de Sousse, Sousse, Tunisie
https://orcid.org/0000-0002-7477-2965

David B. Pyne[120]
[120] Research Institute for Sport and Exercise, University of Canberra, Canberra, ACT, Australia
https://orcid.org/0000-0003-1555-5079

Lee Taylor[121,122,123]
[121] School of Sport, Exercise and Health Sciences, Loughborough University. National Centre for Sport and Exercise Medicine (NCSEM), Loughborough, United Kingdom
[122] Human Performance Research Centre, University of Technology Sydney, Sydney, NSW, Australia
[123] Sport & Exercise Discipline Group, Faculty of Health, University of Technology Sydney, Sydney, NSW, Australia
https://orcid.org/0000-0002-8483-7187

Karim Chamari[5]
[5] Aspetar, Orthopaedic and Sports Medicine Hospital, FIFA Medical Centre of Excellence, Doha, Qatar
https://orcid.org/0000-0001-9178-7678

[#]These authors contributed equally to this work

***Corresponding Author:***

Jad Adrian Washif

National Sports Institute of Malaysia

National Sports Complex, Bukit Jalil,

57000 Kuala Lumpur, Malaysia

Tel: 03-89914400

Fax: 03-89968748

Email: jad@isn.gov.my

| | |
|---|---|
| Running Head: | Lockdown influences on sports and sexes |
| Abstract word count: | 250 words |
| Text-only word count: | 3762 words |
| Number of figures: | 5 |
| Number of tables: | 4 |

**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: $\geq$70% as good, $\geq$51-<70% as moderate, and $\leq$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 ($\chi^2$) 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.

## ACKNOWLEDGEMENTS

The COVID-19-ECBATA (**E**ffects of **C**onfinement on knowledge, **B**eliefs/**A**ttitudes, and **T**raining in **A**thletes) consortium sincerely thank all of those who supported this project, especially the athletes (respondents), and individuals who helped with dissemination of the survey, and sports organizations from >140 countries and territories worldwide.

## FUNDING

No external funding was received in the production of this study.

## COMPETING INTERESTS

The authors declare that they have no competing interests

## REFERENCES


1. Trabelsi K, Ammar A, Masmoudi L, et al. Globally altered sleep patterns and physical activity levels by confinement in 5056 individuals: ECLB COVID-19 international online survey. *Biol Sport.* 2021;38(4):495–506. doi:10.5114/biolsport.2021.101605.
2. Ammar A, Mueller P, Trabelsi K, et al. Psychological consequences of COVID-19 home confinement: The ECLB-COVID19 multicenter study. *PLoS ONE.* 2020;15(11):e0240204. doi:10.1371/journal.pone.0240204.
3. Bok D, Chamari K, Foster C. The pitch invader – COVID-19 cancelled the game: what can science do for us, and what can the pandemic do for science? *Int J Sports Physiol Perform.* 2020;15(7):917–9. doi:10.1123/ijspp.2020-0467.
4. Washif JA, Mohd Kassim SFA, Lew PCF, et al. Athlete's perceptions of a 'quarantine' training camp during the COVID-19 lockdown. *Front Sports Act Living.* 2021;2:622858. doi:10.3389/fspor.2020.62285.
5. Mon-López D, García-Aliaga A, Ginés Bartolomé A, et al. How has COVID-19 modified training and mood in professional and non-professional football players?. *Physiol Behav.* 2020;227:113148. doi:10.1016/j.physbeh.2020.113148.
6. Pillay L, Janse van Rensburg DC, Jansen van Rensburg A, et al. Nowhere to hide: the significant impact of coronavirus disease 2019 (COVID-19) measures on elite and semi-elite South African athletes. *J Sci Med Sport.* 2020;23:670–9. doi:10.1016/j.jsams.2020.05.016.
7. Facer-Childs ER, Hoffman D, Tran JN, et al. Sleep and mental health in athletes during COVID-19 lockdown. *Sleep* 2021;44. doi:10.1093/sleep/zsaa261.
8. Roberts C, Gill N, Sims S. The influence of covid-19 lockdown restrictions on perceived nutrition habits in rugby union players. *Front Nutr.* 2020;7:589737. doi:10.3389/fnut.2020.589737.
9. Stokes KA, Jones B, Bennett M, et al. Returning to play after prolonged training restrictions in professional collision sports. *Int J Sports Med.* 2020. doi:10.1055/a-1180-3692.
10. Peña J, Altarriba-Bartés A, Vicens-Bordas J, et al. Sports in time of COVID-19: Impact of the lockdown on team activity. *Apunts Sports Med.* 2021;56(209):100340. doi:10.1016/j.apunsm.2020.100340.
11. Mon-López D, de la Rubia Riaza A, Galán MH, et al. The impact of COVID-19 and the effect of psychological factors on training conditions of handball players. *Int J Environ Res Public Health* 2020;17(18):6471. doi:10.3390/ijerph17186471.
12. Muriel X, Courel-Ibáñez J, Cerezuela-Espejo V, et al. Training load and performance impairments in professional cyclists during COVID-19 lockdown. *Int J Sports Physiol Perform.* 2020;19:1–4. doi:10.1123/ijspp.2020-0501.
13. Herrera-Valenzuela T, Narrea Vargas JJ, Merlo R, et al. Effect of the COVID-19 quarantine on body mass among combat sports athletes. *Nutr Hosp.* 2020;16;37(6):1186–9. doi:10.20960/nh.03207.

14. Haddad M, Abbes Z, Mujika I, et al. Impact of COVID-19 on swimming training: practical recommendations during home confinement/isolation. *Int J Environ Res Public Health* 2021;18:4767. doi:10.3390/ijerph18094767.

15. de Boer DR, Hoekstra F, Huetink KIM, et al. Physical activity, sedentary behavior and well-being of adults with physical disabilities and/or chronic diseases during the first wave of the COVID-19 pandemic: a rapid review. *Int J Environ Res Public Health.* 2021;18(12):6342. doi:10.3390/ijerph18126342.

16. Yousfi N, Bragazzi NL, Briki W, et al. The COVID-19 pandemic: how to maintain a healthy immune system during the lockdown - a multidisciplinary approach with special focus on athletes. *Biol Sport.* 2020;37(3):211–6. doi:10.5114/biolsport.2020.95125.

17. Zimmerman BJ. *Development and adaptation of expertise: the role of self-regulatory processes and beliefs.* In: The Cambridge Handbook of Expertise and Expert Performance, eds KA Ericsson, N Charness, PJ Feltovich, and RR Hoffman. New York, NY: Cambridge University Press; 2006. p.705–22.

18. Rice SM, Gwyther K, Santesteban-Echarri O, et al. Determinants of anxiety in elite athletes: a systematic review and meta-analysis. *Br J Sports Med.* 2019;53:722–30. doi:10.1136/bjsports-2019-100620.

19. di Fronso S, Costa S, Montesano C, et al. The effects of COVID-19 pandemic on perceived stress and psychobiosocial states in Italian athletes. *Int J Sport Exerc Psychol.* 2020. doi:10.1080/1612197X.2020.1802612.

20. Bruinvels G, Lewis NA, Blagrove RC, et al. COVID-19–Considerations for the female athlete. *Front Sports Act Living.* 2021;3:606799. doi:10.3389/fspor.2021.606799.

21. Washif JA, Farooq A, Krug I, et al. Training during the COVID-19 lockdown: Knowledge, beliefs, and practices of 12,526 athletes from 142 countries and six continents. *Sports Med.* 2022;52(4):933-48. doi:10.1007/s40279-021-01573-z.

22. Gliem J, Gliem R. *Calculating, interpreting, and reporting Cronbach's alpha reliability coefficient for Likert-type scales*. Midwest Research to Practice Conference in Adult, Continuing, and Community Education; 2003.

23. Konings MJ, FJ Hettinga. Pacing decision making in sport and the effects of interpersonal competition: a critical review. *Sports Med.* 2018;48(8):1829–43. doi:10.1007/s40279-018-0937-x.

24. Seiler S. What is best practice for training intensity and duration distribution in endurance athletes? *Int J Sports Physiol Perform.* 2020;5(3):276–91. doi:10.1123/ijspp.5.3.276.

25. Steele J, Androulakis-Korakakis P, Carlson L, et al. The impact of coronavirus (covid-19) related public-health measures on training behaviours of individuals previously participating in resistance training: a cross-sectional survey study. *Sports Med.* 2021;51(7):1561–80. doi:10.1007/s40279-021-01438-5.

26. Jayaweera M, Perera H, Gunawardana B, et al. Transmission of COVID-19 virus by droplets and aerosols: a critical review on the unresolved dichotomy. *Environ Res.* 2020;188:109819. doi:10.1016/j.envres.2020.109819.

27. Mon-López D, Moreira da Silva F, Calero Morales S, et al. What do Olympic shooters think about physical training factors and their performance? *Int J Environ Res Public Health.* 2019;16:4629. doi:10.3390/ijerph16234629.

28. Mujika I, Padilla S. Detraining: Loss of training induced physiological and performance adaptations. Part I: short term insufficient training stimulus. *Sports Med.* 2000;30:79–87. doi:10.2165/00007256-200030020-00002.

29. Spiering BA, Mujika I, Sharp MA, et al. Maintaining physical performance: the minimal dose of exercise needed to preserve endurance and strength over time. *J Strength Cond Res.* 2021;35(5):1449–58. doi:10.1519/JSC.0000000000003964.

30. Hermassi S, Bouhafs EG, Bragazzi NL, et al. Effects of home confinement on the intensity of physical activity during the covid-19 outbreak in team handball according to country, gender, competition level, and playing position: a worldwide study. *Int J Environ Res Public Health.* 2021;18:4050. doi:10.3390/ijerph18084050.

31. Izquierdo M, Ibañez, J, González-BadilloJJ, et al. Detraining and tapering effects on hormonal responses and strength performance. *J Strength Cond Res.* 2007;21(3):768–75. doi:10.1519/00124278-200708000-00019.

32. Lough N, Geurin AN. *Routledge handbook of the business of women's sport.* New York, NY: Routledge. 2019.

33. Costello JT, Bieuzen F, Bleakley CM. Where are all the female participants in Sports and Exercise Medicine research? *Eur J Sport Sci.* 2014;14(8):847–51. doi:10.1080/17461391.2014.911354.

34. Schumacher YO, Tabben M, Hassoun K, et al. Resuming professional football (soccer) during the COVID-19 pandemic in a country with high infection rates: a prospective cohort study. *Br J Sports Med.* 2021. Epub ahead of print. doi:10.1136/bjsports-2020-103724.

35. Washif JA, Ammar A, Trabelsi K, et al. Regression analysis of perceived stress among elite athletes from changes in diet, routine and well-being: effects of the covid-19 lockdown and "bubble" training camps. *Int J Environ Res Public Health* 2022;19(1):402. doi:10.3390/ijerph19010402.

## 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 (0-100%) | BA (0-100%) | Knowledge Male (0-100%) | Knowledge Female (0-100%) | BA Male (0-100%) | BA Female (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<br>**%** | Female<br>**%** | 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);

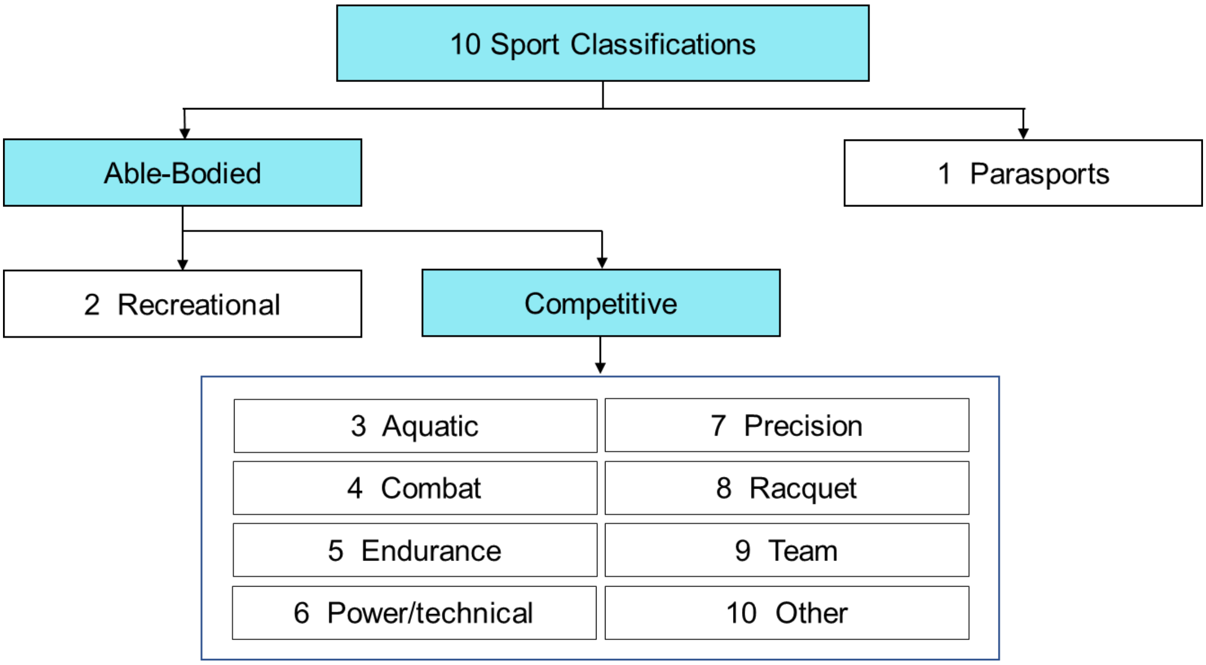


**Figure 1.** Flow diagram outlining sport classification process.

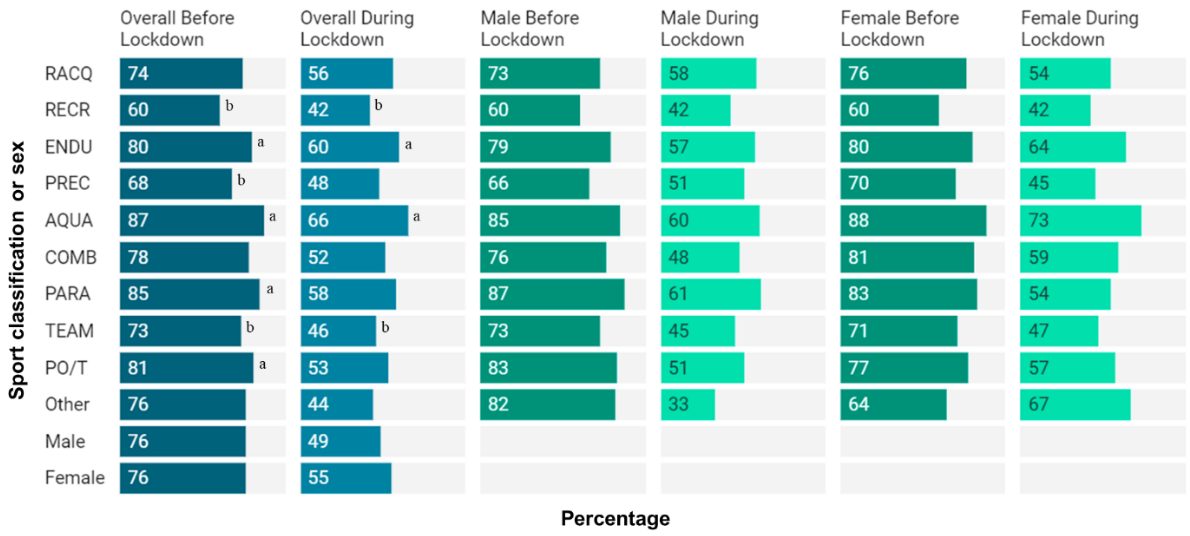


**Figure 2.** Training frequency of ≥5 times per week based on sport classification and sex before and during lockdown (n = 11,626).

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.

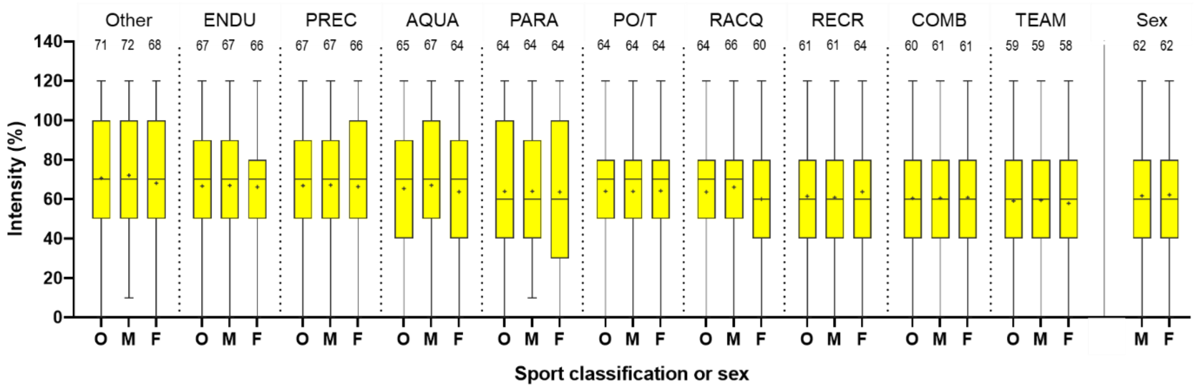


**Figure 4.** Training intensity during lockdown session based on sport classification and sex.

*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.

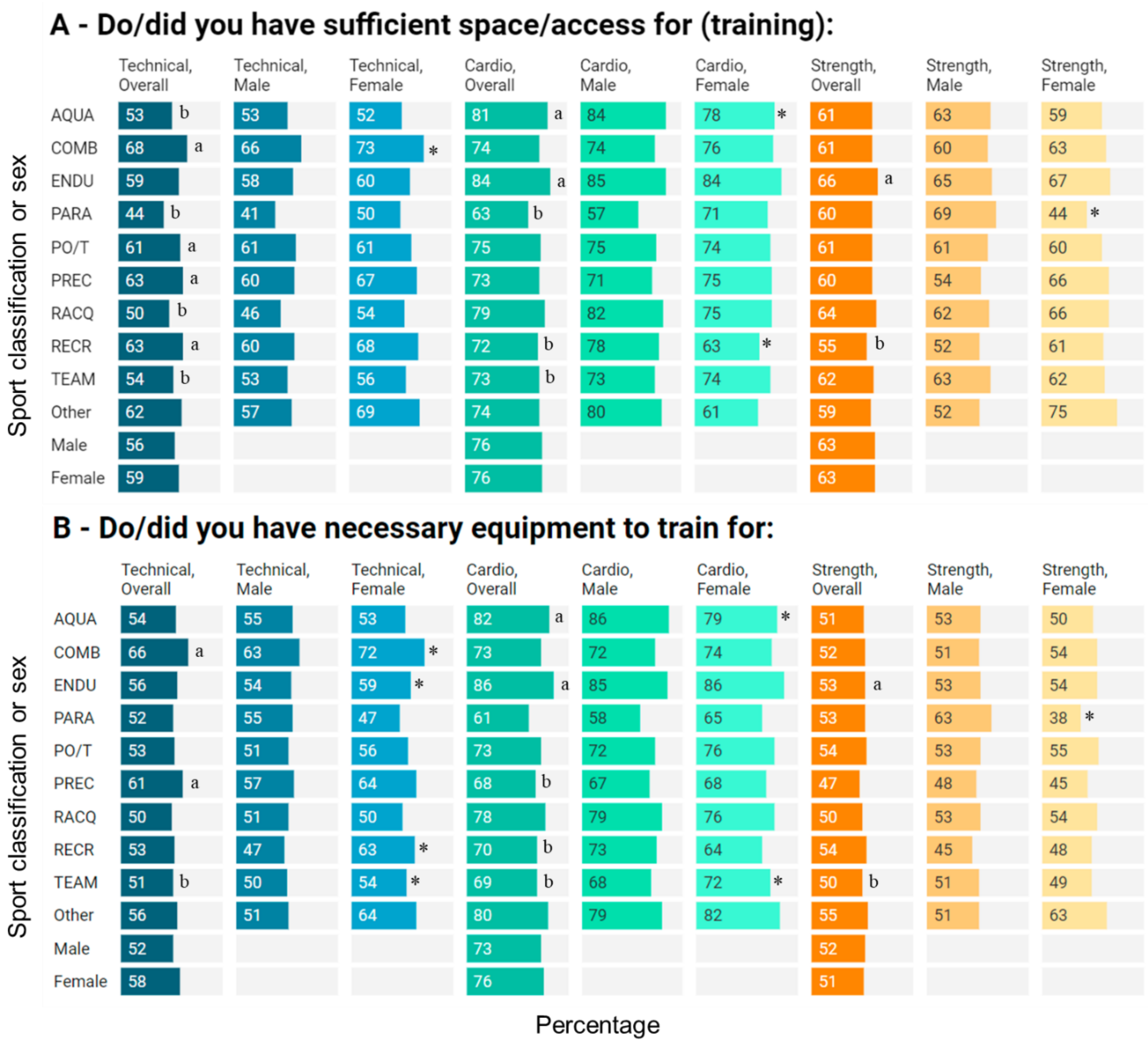


**Figure 5.** Reported practices for space/access and equipment to training based on sport classification and sex (n = 11,451).

*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.