HHS Public Access

Author manuscript

Sports Med. Author manuscript; available in PMC 2020 August 01.

Published in final edited form as:

Sports Med. 2019 August ; 49(8): 1143–1157. doi:10.1007/s40279-019-01133-6.

Exercise Recommendations for Women with Polycystic Ovary Syndrome: Is the Evidence Enough?

Nigel K. Stepto[1,2,3,4], **Rhiannon K. Patten**[1], **Eliza C. Tassone**[2], **Marie L. Misso**[2], **Leah Brennan**[5,6], **Jacqueline Boyle**[2], **Russell A. Boyle**[1], **Cheryce L. Harrison**[2], **Angelica Lindén Hirschberg**[7], **Kate Marsh**[8], **Alba Moreno-Asso**[1,3], **Leanne Redman**[9], **Mala Thondan**[2,10], **Chandrika Wijeyaratne**[11], **Helena J. Teede**[2], **Lisa J. Moran**[2]

[1]Institute for Health and Sport (iHES), Victoria University, Footscray, PO Box 14428, Melbourne, VIC 8001, Australia

[2]Monash Centre for Health Research and Implementation, Monash Public Health and Preventive Medicine, Monash University, Monash Health, Melbourne, VIC, Australia

[3]Australian Institute for Musculoskeletal Science (AIMSS) Victoria University, St Albans, VIC, Australia

[4]Department Medicine Western Health, Faculty of Medicine, Dentistry and Health Sciences, Melbourne University, Melbourne, VIC, Australia

[5]School of Behavioural and Health Sciences, Australian Catholic University, Victoria, Australia

[6]Centre for Eating, Weight and Body Image, Melbourne, VIC, Australia

[7]Department of Women's and Children's Health, Department of Gynecology and Reproductive Medicine, Karolinska Institutet, Karolinska University Hospital, Stockholm, Sweden

[8]Private Practice, Sydney, NSW, Australia

[9]Reproductive Endocrinology and Women's Health Laboratory, Clinical Sciences Division Pennington Biomedical Research Center, Baton Rouge, LA, USA

[10]Harp Family Medical Centre, Kew East, VIC, Australia

[11]Faculty of Medicine, University of Colombo and De Soyza Hospital for Women Colombo, Colombo, Sri Lanka

Abstract

In this opinion piece, we summarize, discuss implications of implementation, and critically evaluate our 2018 evidence-based guideline recommendations for exercise and physical activity in women with polycystic ovary syndrome (PCOS). We developed recommendations as part of a larger international guideline development project. The overall guideline scope and priorities were

Nigel K. Stepto, Nigel.Stepto@vu.edu.au.

Conflict of interest N Stepto, J. Boyle, L. Moran, and H. Teede were named investigators on the NHMRC Centre for Research Excellence in PCOS (APP1078444) grant, but receive no salary from the grant. J. Boyle is a NHMRC Career Development Fellow. M. Misso was employed as the systematic reviewer and guideline developer for the work that informed this article. R. Patten, E. Tassone, L. Brennan, R. Boyle, C. Harrison, A. Lindén Hirschberg, K. Marsh, A. Moreno-Asso, L. Redman, M. Thondan, and C. Wijeyaratne have no conflicts of interest relevant to this article to declare.

informed by extensive health professional and consumer engagement. The lifestyle guideline development group responsible for the exercise recommendations included experts in endocrinology, exercise physiology, gynecology, dietetics, and obstetrics, alongside consumers. Extensive online communications and two face-to-face meetings addressed five prioritized clinical questions related to lifestyle, including the role of exercise as therapy for women with PCOS. The guideline recommendations were formulated based on one narrative and two evidence-based reviews, before consensus voting within the guideline panel. The development process was in accordance with the Appraisal of Guidelines for Research and Evaluation (AGREE) II, and used the Grading of Recommendations, Assessment, Development and Evaluation (GRADE) framework to assess evidence quality, desirable and undesirable consequences, feasibility, acceptability, cost, implementation, and recommendation strength. Given the evidence for exercise as therapy in PCOS being of low quality, a consensus recommendation was made based on current exercise guidelines for the general population. Women with PCOS and clinicians are forced to adopt generic approaches when recommending exercise therapy that perpetuates clinical management with pharmacological solutions. The current status of evidence highlights the need for greater international co-operation between researchers and funding agencies to address key clinical knowledge gaps around exercise therapy in PCOS to generate evidence for appropriate, scalable, and sustainable best practice approaches.

1 Introduction

Polycystic ovary syndrome (PCOS) is the most common endocrine disorder in women of reproductive age, with lifelong repercussions. The prevalence of PCOS varies from 8% to 13% [1], depending on the diagnostic criteria, ethnicity [2, 3], and other factors such as body weight [4]. The Rotterdam criteria, the internationally accepted diagnostic criteria for PCOS, requires any two of the following three criteria; oligo- or anovulation, clinical and/or biochemical hyperandrogenism, and polycystic ovaries, with the exclusion of other aetiologies that may mimic PCOS [5]. In light of this clinical heterogeneity, PCOS can present as one of four phenotypes [6] ranging from mild to severe forms. PCOS is the leading cause of anovulatory infertility among reproductive-aged women [7, 8]. PCOS is underpinned by insulin resistance (IR) and has significant cardio-metabolic features including hypertension, dyslipidemia, vascular dysfunction, obesity, and increased risk of metabolic syndrome and type 2 diabetes [9–17]. PCOS can also have a significant negative impact on health-related quality of life (HRQoL) [18–20] and mental wellbeing [21], with women reporting higher levels of anxiety and depression compared to women without PCOS [21–24].

Physical activity and structured exercise in the general population delivers metabolic, cardiovascular, and psychological benefits at population level, alone or in combination with dietary changes [25–27]. Conversely, sedentary behaviors (activities during waking hours in a seated or reclined position with energy expenditure less than 1.5 times the resting metabolic rate) are linked to all-cause mortality with significant amounts of physical activity (> 60 min per day) required to offset this association [28, 29]. Both aerobic and resistance exercise have proven benefit in reducing cardio vascular risk factors (CVRFs), although combined training seems to be the most effective [30]. It is estimated that the health impact

of exercise therapy can reduce the long-term cost to healthcare systems in people at risk of chronic metabolic disease like pre-diabetes (~ AUD$1900/person/annum [31]) that includes women with PCOS. The benefits of exercise compared to minimal or no intervention in women with PCOS has been described prior [32–34] and subsequent [35, 36] to the international evidence-based guidelines and are limited to a few reported randomized controlled trials (RCTs; Table 1). Further support for the beneficial role of physical activity and exercise in PCOS comes from cohort and case–control studies that report improved cardio-metabolic features (insulin resistance (IR), dyslipidaemia, CVRFs, and vascular function), cardiorespiratory fitness, body composition (waist circumference, central adiposity, and body mass index (BMI)), reproductive features (Anti-Müllerian Hormone [AMH], a marker of ovarian function; menstrual cyclicity and ovulation), and psychological wellbeing in women with PCOS and overweight/obesity [37–50]. The benefits of these interventions often occur independent of significant weight loss [40].

Despite the well-established benefit of physical activity and exercise for prevention of chronic disease and the need for maintenance of health at population level, and particularly in women with PCOS, most populations tend to remain inactive [51]. This disengagement from physical activity and exercise is likely due to general and PCOS-specific barriers [37, 52, 53]. To overcome reduced participation, we need to address the general (time limitations, fatigue, climate, ill health, motivation, self-consciousness about appearance [53]) and PCOS-specific (lack of confidence about maintaining physical activity, fear of injury, physical limitations [37]) barriers, by focusing on effective exercise or physical activities that are enjoyable and likely to be self-sustained beyond the period of therapeutic intervention.

As with pharmacological treatment, physical activity and exercise do not normalise IR [39], nor completely ameliorate the clinical complications of PCOS. Nevertheless, there is a clear role for physical activity and exercise in the management and treatment of PCOS, which has been recognised in previous clinical practice guidelines for women with PCOS [45, 54–57]. However, the previous guidelines lacked scope, stakeholder engagement, and a sound evidence-base, and/or needed updating leaving major gaps in knowledge for appropriate clinical application [58]. Hence, there is a continued need to determine appropriate physical activity and/or exercise “doses,” types and regimes that are efficacious for improving clinical features of PCOS while enhancing patient engagement and long-term sustainability.

We provide a summary of our recommendations to highlight existing limitations of knowledge on exercise therapy and physical activity in PCOS. Additionally, we explore the implications for implementation of recommendations of the 2018 international evidence-based guideline for the treatment and management of PCOS [58, 59]. We also address the data used to answer the common clinical question from women with PCOS and healthcare providers on the existing gaps in clinical practice: In women with PCOS, are exercise interventions (compared to no exercise and/or different exercises) effective for improving anthropometric, cardio-metabolic, reproductive, fertility, quality-of-life, and emotional wellbeing outcomes?

2 Methodological Approach

Best practice evidence-based guideline development methodology was applied and detailed in the full guideline [58]. The international evidence-based guideline development involved health-professional societies and consumer organizations, with multidisciplinary experts and women with PCOS consulted directly at all stages of the process. An international advisory and a project board from six continents, a multidisciplinary international guideline development group, and consumer and translation committees formed the governance team. The international society-nominated panel provided expertise in endocrinology, gynecology, reproductive endocrinology, obstetrics, allied health, and public health, alongside women with PCOS, project management, evidence synthesis, and translation experts. Thirty-seven societies and organizations representing 71 countries were involved in a 15-month process that addressed prioritized clinical questions, of which five were related to weight and lifestyle.

We formed the guideline development group 3—"Lifestyle management and models of care"—where we addressed the key clinical question and knowledge gap related to establishing the physical activity and/or exercise program/intervention that is best suited to target the complex clinical features of PCOS. Using this approach we assessed two evidence-based reviews (Table 1 [32, 33]), one narrative review (Table 1 [34]), and any new RCT meeting the inclusion criteria [58] to inform recommendations on exercise and physical activity alone or within a lifestyle program. Whether we assessed available synthesized evidence or new RCTs, physical activity and exercise programs were classified into three broad categories; aerobic/endurance style activities (focusing on aerobic capacity/fitness), resistance style activities (targeting muscle mass and strength), or a combination of both. These general classifications were further sub-grouped by exercise intensity, especially aerobic style activities or exercises, and can be defined as light, moderate, vigorous, or high-intensity depending on the physiological stress [60]. Appraisal of Guidelines for Research and Evaluation (AGREE) II compliant processes were followed, with extensive evidence synthesis. The Grading of Recommendations, Assessment, Development, and Evaluation (GRADE) framework [61] was applied to assess evidence quality, desirable and undesirable consequences, feasibility, acceptability, cost, implementation, and ultimately recommendation strength. Evidence-based recommendations (EBRs) were formulated before the consensus voting within the guideline panel. In addition to appraised evidence in the new guideline we also report on clinical trials that did not meet the strict criteria for the guidelines to highlight vital knowledge missed that adds context to consensus recommendations.

3 What is the Evidence for the Consensus Recommendation?

To date there is minimal high-quality evidence exploring the type of exercise that best targets the clinical features of PCOS (Tables 1 and 2). The impact of exercise and physical activity on the cardio-metabolic and reproductive features of PCOS have been relatively well summarized in a number of publications [32–34, 44], with little advancement in the most recent literature (Table 1) [35, 36]. While acknowledging the limitations of available evidence (sample size, study type, heterogeneity of interventions; Table 1), the evidence

syntheses and RCTs evaluated do show important clinical improvements induced by exercise interventions in CVRFs, glycaemic control, biomarkers of reproductive health, quality of life, and functional capacities (aerobic fitness, maximal strength), when compared to minimal or no treatment (Tables 1 and 2) [32–36, 42, 44, 45, 62, 63]. When considering which type of exercise may be most beneficial to women with PCOS, it is unclear from the evidence, with the majority of studies ($n = 9$) utilizing aerobic exercise at a moderate to vigorous intensity (Table 2), but in varying modes (walk, run, or ride) and supervision levels. Similarly, exploring whether resistance training, either alone or in combination with aerobic exercise has benefits for women with PCOS, definitive recommendations are not possible. Only three studies meeting the inclusion criteria explore resistance training, where only one study [64] has resistance training only and two utilize combined training [42, 43, 65].

A small RCT has been conducted exploring the effect of intervention duration (12 or 24 weeks) of moderate intensity cycling performed three times per week on a stationary cycle ergometer on the health of women with PCOS [66]. This clearly demonstrated that 24 weeks of intervention had greater clinical impact than 12 weeks on CVRFs and metabolic features [66]. Specifically, at 24 weeks, the markers of glucose homeostasis, lipid profiles (LDL, HDL), and anthropometry (6-cm reduction in waist circumference and 2 kg/m^2 reduction in BMI) showed significantly greater improvement than at 12 weeks, albeit with no impact on the reproductive biomarkers [44, 45, 66]. A second study (a relatively small RCT) [42, 43], explored the impact of the type of exercise by using different 20-week fitness center-based exercise programs (superimposed on a high-protein diet). Aerobic exercise (5 days/week of moderate intensity treadmill walking/jogging) was compared to a combined exercise intervention (3 days/week of moderate intensity treadmill walking/jogging plus 2 days/week of progressive resistance training). Both training interventions elicited similar improvements in CVRFs and metabolic, reproductive, and psychological features of PCOS in parallel with the same diet-induced weight loss in women with PCOS [42–45]. Additionally, in terms of psychological health, community-based/epidemiological studies have demonstrated a positive association of self-reported physical activity levels and improved mental health status [37, 38].

Overall, the lack of high-quality evidence limits recommendations on prescription of specific types and doses of exercise, and any therapeutic interventions are likely to be aligned with international guidelines for physical activity for adults. These would require women with PCOS to undertake a minimum dose of 150 min of physical activity per week. On face value, this seems a substantial commitment to exercise and physical activity, especially considering the ever increasing barrier of “being too time poor” to engage in sustained physical activity and exercise both in the general population [53] and in women with PCOS [37]. Perhaps a more time-efficient approach to exercise is needed. While no large-scale RCTs have been published in this area, epidemiological data [67] and a small RCT using high-intensity intermittent training (HIIT) [64] suggests that vigorous forms of exercise are associated with better health outcomes and reduced cardio-metabolic features in women with PCOS while also addressing the barrier of time limitation.

While beyond the scope of exercise prescription, sedentary behavior is a growing concern with links to all-cause mortality in the general population [28] and warrants consideration in

any evidence-synthesis focusing physical activity. Research into sedentary behaviors in the general population is in its infancy [28] and even less is known about women with PCOS. Initial data indicate women with PCOS spend 30 min more per day sitting than women without PCOS [10]. Therefore, increased efforts in quantifying and developing strategies to reduce sedentary behaviors in this inactive group should be considered due significant current and future health problems.

4 Recommendations

Despite the large body of literature including RCTs (Table 2) and evidence synthesis (Table 1) [32–36], the quality and quantity of evidence for exercise and physical activity in PCOS is not sufficient to support an evidence-based recommendation, but rather a clinical consensus recommendation (CCR). Within the recommendation terms like “should,” “could,” and “should not” have been used. These terms are informed by the nature of the recommendation (evidence or consensus), the GRADE framework [61], and evidence quality, and are independent descriptors reflecting the judgment of the multidisciplinary guideline development group, which included women with PCOS. These terms refer to the overall interpretation and practical application of the recommendation, balancing benefits and harm. “Should” is used where benefits of the recommendation exceed harm, and where the recommendation can be trusted to guide practice. “Could” is used where either the quality of evidence was limited or the available studies demonstrate little clear benefit of one approach over another, or the balance of benefit to harm was unclear. “Should not” is used where there is either a lack of appropriate evidence, or when the harm may outweigh the benefits.

Specifically, there are a limited number of RCTs of sufficiently high quality, often due to sample size and intervention heterogeneity, to enable the development of exercise/physical activity recommendations for women with PCOS. Therefore current literature on PCOS confines the provision of recommendations in the international guidelines to the general population in the context of exercise and physical activity for health, prevention of weight gain, and promotion of weight loss [77, 78]. As such the clinical consensus recommendations for exercise and physical activity for women with PCOS are provided (see Table 3).

5 Considerations for Implementation of the Clinical Consensus Recommendation

It is clear that the recommendations and clinical practice points will have implications for implementation in clinical practices for the patient and treating healthcare providers. These issues are explored in the context of the GRADE framework [61].

5.1 Resource Requirements

Resource requirements will increase with implementation. Irrespective of the exercise program or physical activity recommended, it may result in increased referrals to allied health and certified exercise professionals. This is likely to increase the cost to women with PCOS, healthcare systems, and/or insurance providers. There may also be increased

consultation times and increased utilization of chronic disease management plans that would result in increased costs.

5.2 Cost Effectiveness

Cost effectiveness has not been assessed for exercise therapy in PCOS. Data from other sources suggest regular exercise can reduce the metabolic disease-associated healthcare costs annually [31]. Furthermore, a group-based integrated lifestyle program (exercise and diet) implemented for 6 months reduced the cost of assisted-fertility treatment per live birth by 60-fold [80].

5.3 Equity

Equity will be an important consideration for implementation. Exercise therapy and long-term physical activity programs do not need to be in clinical centers, expensive gyms, or fitness centers. Exercise and physical activity programs can be delivered in community centers and at sporting grounds/facilities in group settings with minimal equipment. As such, implementation of exercise and physical activity recommendations should be provided in the context of the socioeconomic status of the patients and in consideration of health and community services available.

5.4 Acceptability

Acceptability to women with PCOS, clinicians, and healthcare funders is likely to be a challenge for implementing the recommendations. Engagement of healthcare practitioners and healthcare funders, as well as financial barriers, may be an issue for the women. Insufficient access to allied health and certified exercise professionals may also be a barrier, as well as insufficient consultation time allocated by general practitioners and other clinical specialists. Drop-out rates and sustainable long-term engagement to exercise programs may be a problem for women with PCOS, but if there is adequate allied health and clinical support with a patientcenterd approach, this problem may be reduced to similar or better levels of non-compliance than long-term pharmacological treatments.

5.5 Feasibility

Feasibility in current healthcare structures is high. Utilizing current structures for referral into exercise therapy/physical activity programs is already in place in many countries. This makes recommending exercise therapy and/or physical activity to patients by a care team relatively easy, and generally cost effective in a group setting. Solutions to deliver and facilitate long-term increases in physical activity and exercise will be required where these services and structures are not available. Overall, a global shift in cultural mindset with regard to recommending regular exercise and/or physical activity may be required.

5.6 Implementation

Implementation of the exercise therapy/physical activity recommendations into standard care will require:

1. Innovative solutions to provide environments (within and beyond clinical setting) that facilitate all forms of exercise and physical activity.

2. A cultural shift in mindset and additional consultation time from the primary and specialist healthcare providers to educate and discuss the need for exercise and physical activity for women with PCOS. This is likely to involve using chronic disease-management plans and referral mechanisms to certified exercise professionals.
3. Recommendations to exercise must be offered in the context of a woman's individual circumstances (socioeconomic status, goals, likes and dislikes, time constraints)
4. Women with PCOS should be given the opportunity to take control of their exercise therapy and share in the decision making of their care based on the best, valid information from all members of the care team.
5. Accountability and responsibility from both the woman with PCOS and the team of healthcare providers.

5.7 Monitoring and Evaluation

As there is no strong evidence for a specific type, mode, or intensity of exercise being best for the management and treatment of PCOS, recommending expensive cardiorespiratory tests is unwarranted. Instead, simple and easy to use tools would be appropriate to monitor fitness and exercise behaviors in women with PCOS. These tests may include:

1. Simple submaximal fitness tests conducted by certified exercise professionals.
2. Physical activity and sedentary behavior questionnaires (e.g., International Physical Activity questionnaire [IPAQ]), which can be administered by all healthcare providers.
3. Using activity monitors to monitor daily step counts, provide feedback and motivation. Note: these are not medical devices but they do provide valuable insights into physical activity and exercise for all healthcare providers.
4. Quantifying sedentary behaviors and investigating strategies to reduce this behavior in women with PCOS.

However, data on the value of these outcomes in management and treatment does not exist in women with PCOS. Thus, evaluation of these outcomes as health indicators, via health data repositories and clinical trials, may serve to inform further research in the role of exercise in PCOS therapy.

5.8 Research Priorities

Clear clinical research gaps have been identified in this and prior extensive evidence syntheses [32–34, 44, 45], stakeholder feedback in National Health and Medical Research Council (NHMRC) of Australia's Centre for Research Excellence in PCOS, and in research-priority data from an international survey of 1,592 women with PCOS and 1,200 Health Professionals [81]. There is an urgent need to determine:

1. Exercise "doses" and regimes that improve efficacy, engagement, and sustainability of active lifestyles in PCOS management and treatment.

2. The effect of long-term (12 months or greater) exercise studies that focus not only on metabolic health but also fertility (live birth) and mental health, including health-related quality of life.

3. The impact of exercise interventions on clinical features of PCOS in other subpopulations such as lean women, adolescents, and peri-menopausal women.

6 Critical Evaluation

It is clear from assessing even the highest quality evidence that there are high levels of bias stemming from poor reporting of the exercise interventions, intervention heterogeneity, and small sample sizes. These issues are complicit in insufficient evidence for strong recommendations for exercise and/or physical activity interventions in women with PCOS. We might postulate that the reasons for this are multifactorial and stem from:

1. The therapeutic and disease prevention properties of exercise captured in the phrase “exercise is medicine™” is overlooked when there is an apparent pharmacological solution in modern medicine [82].

2. Clinical exercise practice is a new profession and is now only catching up on implementing gold-standard clinical research.

3. Health-research funding is extremely challenging to obtain for therapeutic lifestyle interventions (including exercise), yet alone for PCOS [83].

However, in the context of exercise therapy and interventions in PCOS, there is a multitude of literature (approximately 20 publications including cohort studies and uncontrolled trials) not considered in our rigorous evidence syntheses and practice guidelines [45, 54–57], leaving a “rich source” of evidence unevaluated. These studies, via innovative meta-analysis methodologies, need to be systematically reviewed and analyzed to better inform our understanding of the impact of exercise in women with PCOS. This will directly add to the evidence needed to inform the medical profession and funding agencies that will support missing high-quality clinical trials for women with PCOS and obesity-related diseases more broadly.

In order to advance the current understanding of the benefits of exercise therapy and physical activity in women with PCOS it is clear that a concerted effort is needed where clinicians, allied health practitioners, and specialists engage with women with PCOS to design these studies. Together they should lobby governments and funding agencies to help address the remaining gaps in knowledge and clinical practice. We believe this needs to occur efficiently and collaboratively, where future exercise-based clinical trials address PCOS-specific barriers for sustainability, incorporate behavior change theory, and are:

1. Multidisciplinary (nutrition, psychology, sociology)

2. Multinational

    a. Co-funded internationally

   b. Multi-ethnic, encompassing as many different genetic groups as possible (e.g., the southeast Asians, Europeans, African Americans, Chinese)

   c. Very large sample sizes

3. Are translational

   a. Have capacity for scalability within different socioeconomic contexts

   b. Include educational components for changing clinician attitudes and behaviors

7 Conclusion

There is relatively little evidence from the highest quality clinical trials (RCTs) upon which to base an evidence-based exercise recommendation for women with PCOS. This results in a perpetuation of consensus recommendations for exercise and physical activity applied from the general population data. However, the way forward is to evaluate individual patient data and/or all data from exercise intervention literature (cohort and case–control studies) to garner a better understanding on the health impact of exercise in women with PCOS. These assessments should then be used to inform the next series of exercise intervention studies. Overall, a stronger body of evidence is required, highlighting the need to advocate for funding for large RCTs that are co-designed with women and clinicians to facilitate engagement, sustainability, and incorporation into clinical care, and are appropriate across the socioeconomic context.

Acknowledgements

The authors extend many thanks to the Exercise and Sports Science Australia (ESSA) Special Interest Group who provided critical feedback on the recommendation summary.

Funding This work was supported with funding from the National Health and Medical Research Council (NHMRC) Centre for Research Excellence in PCOS (APP1078444), American Society for Reproductive Medicine (ASMR) and European Society of Human Reproduction and Embryology (ESRHE).

References

1. Bozdag G, Mumusoglu S, Zengin D, Karabulut E, Yildiz BO. The prevalence and phenotypic features of polycystic ovary syndrome: a systematic review and meta-analysis. Hum Reprod. 2016;31(12):2841–55. [PubMed: 27664216]
2. Boyle JA, Cunningham J, O'Dea K, Dunbar T, Norman RJ. Prevalence of polycystic ovary syndrome in a sample of Indigenous women in Darwin, Australia. Med J Aust. 2012;196:62–6. [PubMed: 22256938]
3. Goodarzi MO, Quiñones MJ, Azziz R, Rotter JI, Hsueh WA, Yang H. Polycystic ovary syndrome in Mexican-Americans: prevalence and association with the severity of insulin resistance. Fertil Steril. 2005;84:766–9. [PubMed: 16169421]
4. Teede HJ, Joham AE, Paul E, Moran LJ, Loxton D, Jolley D, et al. Longitudinal weight gain in women identified with polycystic ovary syndrome: results of an observational study in young women. Obesity. 2013;21:1526–32. [PubMed: 23818329]
5. The Rotterdam ESHRE/ASRM-Sponsored PCOS Consensus Workshop Group. Revised 2003 consensus on diagnostic criteria and long-term health risks related to polycystic ovary syndrome. Fertil Steril. 2004;81:19–25.

6. NIH. National Institutes Of Health, Evidence-based Methodology Workshop on Polycystic Ovary Syndrome. 2012 accessed on 10 August 2017 (https://prevention.nih.gov/research-priorities/research-needs-and-gaps/pathways-prevention/evidence-based-methodology-workshop-polycystic-ovary-syndrome-pcos).
7. Dokras A. Cardiovascular disease risk factors in polycystic ovary syndrome. Semin Reprod Med. 2008;26:39–44. [PubMed: 18181081]
8. Yildiz BO, Bozdag G, Yapici Z, Esinler I, Yarali H. Prevalence, phenotype and cardiometabolic risk of polycystic ovary syndrome under different diagnostic criteria. Hum Reprod.2012;27:3067–73. [PubMed: 22777527]
9. Cussons AJ, Watts GF, Burke V, Shaw J, Zimmet PZ, Stuckey BG. Cardiometabolic risk in polycystic ovary syndrome: a comparison of different approaches to defining the metabolic syndrome. Hum Reprod.2008;23:2352–8. [PubMed: 18635531]
10. Moran LJ, Ranasinha S, Zoungas S, McNaughton SA, Brown WJ, Teede HJ. The contribution of diet, physical activity and sedentary behaviour to body mass index in women with and without polycystic ovary syndrome. Hum Reprod.2013;28:2276–83. [PubMed: 23771201]
11. Moran LJ, Strauss BJ, Teede HJ. Diabetes risk score in the diagnostic categories of polycystic ovary syndrome. Fertil Steril.2011;95:1742–8. [PubMed: 21316662]
12. Stepto NK, Cassar S, Joham AE, Hutchison SK, Harrison CL, Goldstein RF, et al. Women with polycystic ovary syndrome have intrinsic insulin resistance on euglycaemic–hyperinsulaemic clamp. Hum Reprod.2013;28:777–84. [PubMed: 23315061]
13. Cassar S, Misso ML, Hopkins WG, Shaw CS, Teede HJ, Stepto NK. Insulin resistance in polycystic ovary syndrome: a systematic review and meta-analysis of euglycaemic–hyperinsulinaemic clamp studies. Hum Reprod.2016;31(11):2619–31. [PubMed: 27907900]
14. Moran LJ, Cameron JD, Strauss BJ, Teede HJ. Vascular function in the diagnostic categories of polycystic ovary syndrome. Hum Reprod.2011;26(8):2192–9. [PubMed: 21616917]
15. Sprung VS, Atkinson G, Cuthbertson DJ, Pugh CJ, Aziz N, Green DJ, et al. Endothelial function measured using flow-mediated dilation in polycystic ovary syndrome: a meta-analysis of the observational studies. Clin Endocrinol.2013;78(3):438–46.
16. Sprung VS, Jones H, Pugh CJ, Aziz NF, Daousi C, Kemp GJ, et al. Endothelial dysfunction in hyperandrogenic polycystic ovary syndrome is not explained by either obesity or ectopic fat deposition. Clinical science (London, England: 1979). 2014;126(1):67–74.
17. Kakoly NS, Moran LJ, Teede HJ, Joham AE. Cardiometabolic risks in PCOS: a review of the current state of knowledge. Expert Review of Endocrinology Metabolism. 2019 2019/01/02;14(1):23–33. [PubMed: 30556433]
18. Barnard L, Ferriday D, Guenther N, Strauss B, Balen AH, Dye L. Quality of life and psychological well being in polycystic ovary syndrome. Hum Reprod.2007;22:2279–86. [PubMed: 17537782]
19. Hahn S, Janssen OE, Tan S, Pleger K, Mann K, Schedlowski M, et al. Clinical and psychological correlates of quality-of-life in polycystic ovary syndrome. Eur J Endocrinol.2005;153:853–60. [PubMed: 16322391]
20. Li Y, Li Y, Yu Ng EH, Stener-Victorin E, Hou L, Wu T, et al. Polycystic ovary syndrome is associated with negatively variable impacts on domains of health-related quality of life: evidence from a meta-analysis. Fertil Steril.2011;96:452–8. [PubMed: 21703610]
21. Deeks AA, Gibson-Helm ME, Paul E, Teede HJ. Is having polycystic ovary syndrome a predictor of poor psychological function including anxiety and depression? Hum Reprod.2011;26(6):1399–407. [PubMed: 21436137]
22. Benson S, Hahn S, Tan S, Mann K, Janssen OE, Schedlowski M, et al. Prevalence and implications of anxiety in polycystic ovary syndrome: results of an internet-based survey in Germany. Hum Reprod.2009;24:1446–51. [PubMed: 19223290]
23. Cinar N, Kizilarslanoglu MC, Harmanci A, Aksoy DY, Bozdag G, Demir B, et al. Depression, anxiety and cardiometabolic risk in polycystic ovary syndrome. Hum Reprod.2011;26:3339–45. [PubMed: 21984577]
24. Laggari V, Diareme S, Christogiorgos S, Deligeoroglou E, Christopoulos P, Tsiantis J, et al. Anxiety and depression in adolescents with polycystic ovary syndrome and Mayer-Rokitansky-Küster Hauser syndrome. J Psychosom Obstet Gynaecol.2009;30:83–8. [PubMed: 19533486]

25. Barry VW, Baruth M, Beets MW, Durstine JL, Liu J, Blair SN. Fitness vs. Fatness on all-cause mortality: a meta-analysis. Progress Cardiovascular Diseases. 2014;56(4):382–90.
26. Koivula RW, Tornberg AB, Franks PW. Exercise and diabetes related cardiovascular disease: systematic review of published evidence from observational studies and clinical trials. Curr Diab Rep. 2013;13(3):372–80. [PubMed: 23494754]
27. Nicolucci A. Relationship of exercise volume to improvements of quality of life with supervised exercise training in patients with type 2 diabetes in a randomised controlled trial: the Italian Diabetes and Exercise Study (IDES). Diabetologia.2012;55(3):579–88. [PubMed: 22234648]
28. Biddle SJH, Bennie JA, Bauman AE, Chau JY, Dunstan D, Owen N, et al. Too much sitting and all-cause mortality: is there a causal link? BMC Public Health.2016;16:635. [PubMed: 27456959]
29. Ekelund U, Steene-Johannessen J, Brown WJ, Fagerland MW, Owen N, Powell KE, et al. Does physical activity attenuate, or even eliminate, the detrimental association of sitting time with mortality? A harmonised meta-analysis of data from more than 1 million men and women. Lancet 388(10051):1302–10.
30. Snowling NJ, Hopkins WG. Effects of Different Modes of Exercise Training on Glucose Control and Risk Factors for Complications in Type 2 Diabetic Patients: A meta-analysis. Diabetes Care 2006;29(11):2518–27. [PubMed: 17065697]
31. Access Deloitte. Value of Accredited Exercise Physiologists in Australia. Australia: Exercise & Sports Science Australia; 2015 accessed on 10 August 2017 (https://www.essa.org.au/wp-content/uploads/2015/10/Deloitte-Report-2015_Value-of-AEPs-in-Australia.pdf).
32. Haqq L, McFarlane J, Dieberg G, Smart N. Effect of lifestyle intervention on the reproductive endocrine profile in women with polycystic ovarian syndrome: a systematic review and meta-analysis. Endocrine Connect 2014;3(1):36–46.
33. Haqq L, McFarlane J, Dieberg G, Smart N. The effect of lifestyle intervention on body composition, glycemic control, and cardiorespiratory fitness in polycystic ovarian syndrome: a systematic review and meta-analysis. Int J Sport Nutr Exerc Metab. 2015;25(6):533–40. [PubMed: 24668721]
34. Harrison CL, Lombard CB, Moran LJ, Teede HJ. Exercise therapy in polycystic ovary syndrome: a systematic review. Hum Reprod. 201117(2):171–83.
35. Kite C, Lahart IM, Afzal I, Broom DR, Randeva H, Kyrou I, et al. Exercise, or exercise and diet for the management of polycystic ovary syndrome: a systematic review and meta-analysis. Syst Rev. 2019;8(1):51. [PubMed: 30755271]
36. Benham JL, Yamamoto JM, Friedenreich CM, Rabi DM, Sigal RJ. Role of exercise training in polycystic ovary syndrome: a systematic review and meta-analysis. Clin Obes. 2018
37. Banting LK, Gibson-Helm ME, Polman RE, Teede HJ, Stepto NK. Physical activity and mental health in women with Polycystic Ovary Syndrome. BMC Women's Health. 2014;14(51).
38. Deeks AA, Gibson-Helm ME, Teede HJ. Anxiety and depression in polycystic ovary syndrome: a comprehensive investigation. Fertil Steril. 2010;93(7):2421–3. [PubMed: 20117778]
39. Harrison CL, Stepto NK, Hutchison SK, Teede HJ. The impact of intensified exercise training on insulin resistance and fitness in overweight and obese women with and without polycystic ovary syndrome. Clin Endocrinol. 2012;76(3):351–7.
40. Hutchison SK, Stepto NK, Harrison CL, Moran LJ, Strauss BJ, Teede HJ. Effects of exercise on insulin resistance and body composition in overweight and obese women with and without polycystic ovary syndrome. J Clin Endocrinol Metab. 2011;96(1):E48–56. [PubMed: 20926534]
41. Moran LJ, Harrison CL, Hutchison SK, Stepto NK, Strauss BJ, Teede HJ. Exercise decreases anti-mullerian hormone in anovulatory overweight women with polycystic ovary syndrome: a pilot study. Horm Metabol Res 2011;43(13):977–9.
42. Thomson RL, Buckley JD, Lim SS, Noakes M, Clifton PM, Norman RJ, et al. Lifestyle management improves quality of life and depression in overweight and obese women with polycystic ovary syndrome. Fertil Steril.2010;94(5):1812–6. [PubMed: 20004371]
43. Thomson RL, Buckley JD, Noakes M, Clifton PM, Norman RJ, Brinkworth GD. The effect of a hypocaloric diet with and without exercise training on body composition, cardiometabolic risk profile, and reproductive function in overweight and obese women with polycystic ovary syndrome. J Clin Endocrinol Metab.2008;93(9):3373–80. [PubMed: 18583464]

44. Jean Hailes for Women's Health on behalf of the PCOS Australian Alliance. Evidence-based guidelines for the assessment and management of polycystic ovary syndrome Melbourne: Jean Hailes for Women's Health on behalf of the PCOS Australian Alliance; 2015 accessed 10 August 2017 (www.managingpcos.org.au).
45. Teede HJ, Misso ML, Deeks AA, Moran LJ, Stuckey BGA, Wong JLA, et al. Assessment and management of polycystic ovary syndrome: summary of an evidence-based guideline. Med J Aust. 2011;195(6): S65–112. [PubMed: 21929505]
46. Scott D, Harrison CL, Hutchison S, de Courten B, Stepto NK. Exploring factors related to changes in body composition, insulin sensitivity and aerobic capacity in response to a 12-week exercise intervention in overweight and obese women with and without polycystic ovary syndrome. PLoS One. 2017;12(8): e0182412. [PubMed: 28771628]
47. Nybacka A, Carlstrom K, Fabri F, Hellstrom PM, Hirschberg AL. Serum antimullerian hormone in response to dietary management and/or physical exercise in overweight/obese women with polycystic ovary syndrome: secondary analysis of a randomized controlled trial. Fertil Steril. 2013;100(4):1096–102. [PubMed: 23876536]
48. Nybacka A, Carlstrom K, Stahle A, Nyren S, Hellstrom PM, Hirschberg AL. Randomized comparison of the influence of dietary management and/or physical exercise on ovarian function and metabolic parameters in overweight women with polycystic ovary syndrome. Fertil Steril. 2011;96(6):1508–13. [PubMed: 21962963]
49. Nybacka A, Hellstrom PM, Hirschberg AL. Increased fibre and reduced trans fatty acid intake are primary predictors of metabolic improvement in overweight polycystic ovary syndrome-Substudy of randomized trial between diet, exercise and diet plus exercise for weight control. Clin Endocrinol. 2017;87(6):680–8.
50. Sprung VS, Cuthbertson DJ, Pugh CJ, Aziz N, Kemp GJ, Daousi C, et al. Exercise training in polycystic ovarian syndrome enhances flow-mediated dilation in the absence of changes in fatness. Med Sci Sports Exerc. 2013;45(12):2234–42. [PubMed: 24240117]
51. Moran LJ, Brown WJ, McNaughton SA, Joham AE, Teede HJ. Weight management practices associated with PCOS and their relationships with diet and physical activity. Hum Reprod. 2017;32(3):669–78. [PubMed: 28069732]
52. Conte F, Banting L, Teede HJ, Stepto NK. Mental health and physical activity in women with polycystic ovary syndrome: a brief review. Sports Med. 2015;45(4):497–504. [PubMed: 25430602]
53. Trost SG, Owen N, Bauman AE, Sallis JF, Brown W. Correlates of adults' participation in physical activity: review and update. Med Sci Sports Exerc. 2002;34(12):1996–2001. [PubMed: 12471307]
54. Balen AH, Morley LC, Misso M, Franks S, Legro RS, Wijeyaratne CN, et al. The management of anovulatory infertility in women with polycystic ovary syndrome: an analysis of the evidence to support the development of global WHO guidance. Hum Reprod Update.2016;22(6):687–708. [PubMed: 27511809]
55. Conway G, Dewailly D, Diamanti-Kandarakis E, Escobar-Morreale HF, Franks S, Gambineri A, et al. The polycystic ovary syndrome: a position statement from the European Society of Endocrinology. Eur J Endocrinol. 2014;171(4):P1–29. [PubMed: 24849517]
56. Goodman NF, Cobin RH, Futterweit W, Glueck JS, Legro RS, Carmina E. American Association of Clinical Endocrinologists, American College of Endocrinology, and Androgen Excess and PCOS Society disease state clinical review: guide to the best practices in the evaluation and treatment of polycystic ovary syndrome—part 2. Endoc Pract.2015;21(12):1415–26.
57. Legro RS, Arslanian SA, Ehrmann DA, Hoeger KM, Murad MH, Pasquali R, et al. Diagnosis and treatment of polycystic ovary syndrome: an endocrine society clinical practice guideline. J Clin Endocrinol Metab. 2013;98(12):4565–92. [PubMed: 24151290]
58. Teede HJ, Misso ML, Costello MF, Dokras A, Laven J, Moran L, et al. International evidence-based guideline for the assessment and management of polycystic ovary syndrome. 2018 https://www.monash.edu/medicine/sphpm/mchri/pcos/guideline.
59. Teede HJ, Misso ML, Costello MF, Dokras A, Laven J, Moran L, et al. Recommendations from the international evidence-based guideline for the assessment and management of polycystic ovary syndrome. Fertil Steril. 2018;110(3):364–79. [PubMed: 30033227]

60. Norton K, Norton L, Sadgrove D. Position statement on physical activity and exercise intensity terminology. J Sci Med Sport. 2010;13(5):496–502. [PubMed: 20005170]
61. Group TGW. GRADE handbook for grading quality of evidence and strength of recommendation; 2009
62. Ramos FKP, Lara LADS, Kogure GS, Silva RC, Ferriani RA, Silva MF, et al. Quality of life in women with polycystic ovary syndrome after a program of resistance exercise training. Rev Bras Ginecol Obstet. 2016;38(7):340–7. [PubMed: 27472811]
63. Vizza L, Smith CA, Swaraj S, Agho K, Cheema BS. The feasibility of progressive resistance training in women with polycystic ovary syndrome: a pilot randomized controlled trial. BMC Sports Sci Med Rehabil. 2016;8(1):14. [PubMed: 27175282]
64. Almenning I, Rieber-Mohn A, Lundgren KM, Shetelig Løvvik T, Garnæs KK, Moholdt T. Effects of high intensity interval training and strength training on metabolic, cardiovascular and hormonal outcomes in women with polycystic ovary syndrome: a pilot study. PLoS One. 2015;10(9): e0138793. [PubMed: 26406234]
65. Bruner B, Chad K, Chizen D. Effects of exercise and nutritional counseling in women with polycystic ovary syndrome. Appl Physiol Nutr.2006;31(4):384–91.
66. Orio F, Giallauria F, Palomba S, Manguso F, Orio M, Tafuri D, et al. Metabolic and cardiopulmonary effects of detraining after a structured exercise training programme in young PCOS women. Clin Endocrinol. 2008;68(6):976–81.
67. Greenwood EA, Noel MW, Kao C-N, Shinkai K, Pasch LA, Cedars MI, et al. Vigorous exercise is associated with superior metabolic profiles in polycystic ovary syndrome independent of total exercise expenditure. Fertil Steril.2016;2016(2):486–93.
68. Brown AJ, Setji TL, Sanders LL, Lowry KP, Otvos JD, Kraus WE, et al. Effects of exercise on lipoprotein particles in women with polycystic ovary syndrome. Med Sci Sports Exerc. 2009;41(3):497–504. [PubMed: 19204602]
69. Hoeger KM, Kochman L, Wixom N, Craig K, Miller RK, Guzick DS. A randomized, 48-week, placebo-controlled trial of intensive lifestyle modification and/or metformin therapy in overweight women with polycystic ovary syndrome: a pilot study. Fertil Steril.2004;82(2):421–9. [PubMed: 15302293]
70. Ladson G, Dodson WC, Sweet SD, Archibong AE, Kunselman AR, Demers LM, et al. The effects of metformin with lifestyle therapy in polycystic ovary syndrome: a randomized double-blind study. Fertil Steril.2011;95(3):1059. [PubMed: 21193187]
71. Orio F, Muscogiuri G, Giallauria F, Savastano S, Bottiglieri P, Tafuri D, et al. Oral contraceptives versus physical exercise on cardiovascular and metabolic risk factors in women with polycystic ovary syndrome: a randomized controlled trial. Clin Endocrinol. 2016;85(5):764–71.
72. Stener-Victorin E, Jedel E, Janson PO, Sverrisdottir YB. Low-frequency electroacupuncture and physical exercise decrease high muscle sympathetic nerve activity in polycystic ovary syndrome. Am J Physiol Regul Integr Comp Physiol. 2009;297(2): R387–95. [PubMed: 19494176]
73. Jedel E, Labrie F, Oden A, Holm G, Nilsson L, Janson PO, et al. Impact of electro-acupuncture and physical exercise on hyperan-drogenism and oligo/amenorrhea in women with polycystic ovary syndrome: a randomized controlled trial. Am J Physiol Endocrinol Metab.2011;300(1):E37–45. [PubMed: 20943753]
74. Stener-Victorin E, Baghaei F, Holm G, Janson PO, Olivecrona G, Lonn M, et al. Effects of acupuncture and exercise on insulin sensitivity, adipose tissue characteristics, and markers of coagulation and fibrinolysis in women with polycystic ovary syndrome: secondary analyses of a randomized controlled trial. Fertil Steril. 2012;97(2):501–8. [PubMed: 22154367]
75. Thomson RL, Buckley JD, Brinkworth GD. Perceived exercise barriers are reduced and benefits are improved with lifestyle modification in overweight and obese women with polycystic ovary syndrome: a randomised controlled trial. BMC Womens Health. 2016;9(16):14.
76. Vigorito C, Giallauria F, Palomba S, Cascella T, Manguso F, Lucci R, et al. Beneficial effects of a three-month structured exercise training program on cardiopulmonary functional capacity in young women with polycystic ovary syndrome. J Clin Endocrinol Metab. 2007;92(4):1379–84. [PubMed: 17264174]

77. Donnelly JE, Blair SN, Jakicic JM, Manore MM, Rankin JW, Smith BK. Appropriate physical activity intervention strategies for weight loss and prevention of weight regain for adults. Med Sci Sports Exerc.2009;41(2):459–71. [PubMed: 19127177]

78. Garber CE, Blissmer B, Deschenes MR, Franklin BA, Lamonte MJ, Lee I-M, et al. Quantity and quality of exercise for developing and maintaining cardiorespiratory, musculoskeletal, and neuromotor fitness in apparently healthy adults: guidance for prescribing exercise. Med Sci Sports Exerc. 2011;43(7):1334–59. [PubMed: 21694556]

79. Jakicic JM, Davis KK, Rogers RJ, et al. Effect of wearable technology combined with a lifestyle intervention on long-term weight loss: the idea randomized clinical trial. JAMA. 2016;316(11): 1161–71. [PubMed: 27654602]

80. Clark AM, Thornley B, Tomlinson L, Galletley C, Norman RJ. Weight loss in obese infertile women results in improvement in reproductive outcome for all forms of fertility treatment. Hum Reprod. 1998;13(6):1502–5. [PubMed: 9688382]

81. Gibson-Helm ME, Teede HJ, Dokras A. Delayed diagnosis and a lack of information associated with dissatisfaction in women with polycystic ovary syndrome. J Clin Endocrinol Metab. 2017;102(2):604–12. [PubMed: 27906550]

82. Sallis RE, Matuszak JM, Baggish AL, Franklin BA, Chodzko-Zajko W, Fletcher BJ, et al. Call to action on making physical activity assessment and prescription a medical standard of care. Curr Sports Med Rep. 2016;15(3):207–14. [PubMed: 27172086]

83. Rodgers R, Avery J, Moore V, Davies M, Azziz R, Stener-Victorin E, et al. Complex diseases and co-morbidities: polycystic ovary syndrome and type 2 diabetes mellitus. Endocr Connect. 2019;8(3):R71–5. 10.1530/EC-18-0502.

Key Points

PCOS is a complex endocrinopathy affecting 8–13% of women worldwide and impacting reproductive, cardio-metabolic, and psychological health. Lifestyle modification (behavior, diet, and/or exercise) is recommended as first-line therapy. However, is the evidence strong enough?

Best-practice evidence synthesis for guideline development found limitations in the current body of evidence. This resulted in a consensus statement on exercise recommendations that reflects the physical activity guidelines for health maintenance and weight loss of the general population.

In view of the paucity of quality evidence, new approaches are needed to evaluate the many exercise intervention studies hitherto conducted on women with PCOS. Additionally, large randomized controlled trials are recommended through international collaboration.

Table 1

Summary of current systematic reviews and meta-analyses that informed the evidence-based guideline consensus recommendations (Table 3) [58, 59]

Authors	Review type	Interventions of interest	Comparison group	Outcome measures	Main outcomes/findings	Limitations	Recommendations for future exercise interventions
Harrison et al. [34]	Systematic review of RCTs and cohort studies	Any study that included exercise therapy (aerobic and/or resistance)	No therapy, minimal therapy (standard advice only), or another non-exercise therapy	Cardiovascular risk factors—IR, lipid profiles, blood pressure, weight Reproductive measures—ovulation, menstrual regularity, fertility outcomes	Exercise improved ovulation, reduced IR (9–30%) and promoted weight loss (4.5–10%)	Limitations are restricted to the included studies' risk of bias, as no meta-analysis was conducted	Larger, more comprehensive, and better designed studies RCTs
Haqq et al. [32]	Systematic review and meta-analysis of RCTs	Lifestyle (diet and exercise) or exercise-alone	Usual care (sedentary control, placebo, diet only, or medication)	LH, FSH, SHBG, total T, free T, A, FAI, LH:FSH, E_2, and FG score	Exercise alone improved SHBG, total T, FAI, A, and FG score Lifestyle also improved LH and FSH	Underpowered sample size. Moderate to high between-study heterogeneity with some outcomes	Compare and evaluate the relative effects of exercise alone vs. exercise plus diet
Haqq et al. [33]	Systematic review and meta-analysis of RCTs	Lifestyle (diet and exercise) or exercise-alone	Sedentary control, placebo, diet only, or metformin	BMI, body weight, WC, BF %, W/H ratio, glycaemic parameters (insulin, glucose, HOMA-IR), lipids, CRP, resting heart rate, and VO_{2peak}	Exercise alone improved BMI, WC, resting HR, and VO_{2peak} Lifestyle improved BMI, WC, W/H ratio, BF %, CRP and VO_{2peak} No improvements in insulin, lipid profile or total cholesterol	Varying exercise prescriptions. Use of default *P* values when not reported. Heterogeneity was high in some analyses	None
Benham et al. [36][a]	Systematic review of RCTs, non RCTs and uncontrolled trials, with meta-analysis of RCTs	Any exercise intervention	Individuals with PCOS that are not participating in a dedicated exercise intervention	Primary outcomes—menstrual regularity, menstrual cycle length, luteal phase length, ovulation rate, pregnancy or live births Secondary outcomes—hirsutism, acne, adherence to exercise, follow-up rate, BMI, WC, BF %, HbA1c, plasma glucose and insulin, insulin sensitivity index, TC, LDL, HDL, triglycerides, blood pressure, cardiorespiratory fitness, liver enzymes, liver ultrasounds, HRQoL, depression, and self-esteem	Semi-quantitative analysis suggests exercise improves menstrual regularity, pregnancy and ovulation rates On meta-analysis exercise improved lipid profiles, WC, systolic blood pressure, and fasting insulin	Included studies were highly heterogeneous with respect to exercise intervention design, reported outcomes and reporting of these outcomes	Well-designed trials examining the impact of specific exercise interventions on reproductive health outcomes are required
Kite et al. [35][a]	Systematic review and meta-analysis of RCTs and quasi-RCTs	Any intervention that included exercise	Usual care/control, diet only, pharmaceutical	Primary outcomes—blood pressure, lipids, glucose Secondary outcomes—cardiorespiratory fitness, anthropometric measures, androgen levels, pro-inflammatory markers, and psychological outcomes	Exercise improved fasting insulin, HOMA-IR, TC, LDL, triglycerides, $V0_{2max}$, WC, and body fat percentage Exercise also improves SF-36 domains (physical function, general health,	Included insufficiently powered studies	Future studies should be rigorously designed and sufficiently powered Future studies should also include a dietary component alongside exercise to align with current treatment recommendations

Sports Med. Author manuscript; available in PMC 2020 August 01.

Authors	Review type	Interventions of interest	Comparison group	Outcome measures	Main outcomes/findings	Limitations	Recommendations for future exercise interventions
					social functioning, and mental health)		

IR insulin resistance, *LH* luteinizing hormone, *FSH* follicle stimulating hormone, *SHBG* sex hormone binding globulin, *T* testosterone, *A* androstenedione, *FAI* Free Androgen Index, E_2 estradiol, *FG* Ferriman-Gallwey score, *BMI* body mass index, *PCOS* polycystic ovary syndrome, *WC* waist circumference, *BF %* body fat percentage, *W/H* waist to hip ratio, *HOMA-IR* Homeostatic Model Assessment of Insulin Resistance, VO_{2peak} peak oxygen consumption, *CRP* C-reactive protein, *HbA1c* haemoglobin A1c, *TC* total cholesterol, *LDL* low density lipoproteins, *HDL* high density lipoproteins

[a] Evidence synthesis not considered in consensus recommendation due to publication date being post guideline activities and/or publication

Table 2

Summary table of randomized controlled trials assessed for the International Evidence-based Guidelines Clinical Consensus Statement (Table 3) [58, 59]

Study	Design	Exercise N (total N)	Participant characteristics	PCOS diagnostic criteria	Intervention characteristics	Comparison	Cardiorespiratory and body composition outcomes	Cardio-metabolic outcomes	Hormonal reproductive outcomes
Almenning et al. [64]	RCT	HIIT = 8 RT = 8 (25)	Age = 27.2 HIIT BMI = 26.1 ±6.5 RT BMI = 27.4±6.9	Rotterdam	Type: HIIT or RT Frequency: 3/week Intensity: Vigorous Duration: 10 weeks Supervision: Partial	Usual care - standard exercise recommendations	HIIT: ↑ $V0_{2peak}$No change in RT: $V0_{2peak}$ HIIT:↓ BF %, ↓ FM No change in weight, BMI, WC FFM RT: ↓ BF % ↑ FFM No change in weight, BMI, WC FM	HIIT: ↓ HOMA-IR, ↓ Fasting Insulin, ↑ HDL, ↑ endothelial function No change in fasting glucose, TC, LDL. RT: No change in fasting glucose, fasting insulin, HOMA-IR, TC, HDL, LDL	HIIT: ↓ DHEAS No change in T, FAI, AMH, SHBG. RT: ↓ AMH ↑ SHBG, ↓ FAI No change in T, DHEAS
Brown et al. [68]	RCT	8 (20)	Age = 36.5 (IQR-5) BMI = 37.9 (IQR-9.4)	NIH	Type: Aerobic Frequency: 3–5/week Intensity: Moderate (50% VO_{2max}) Duration: 20–24 weeks Supervision: Full	Control group	↑ VO_{2peak} No change in weight, BMI, WC	No change in HOMA-IR, fasting glucose, fasting insulin, $AUC_{glucose}$, $AUC_{insulin}$.	Not measured
Bruner et al. [65]	RCT (pilot)	7(12)	Age = 32.3 ±1 BMI = 36.2±2	Rotterdam	Type: Aerobic and RT (1/week nutrition sessions) Frequency: 3/week Intensity: Vigorous (70–85% HR_{max}) Duration: 12 weeks Supervision: Full	Nutritional counselling only	↑ VO_{2peak} ↓ WC. No change in weight, BMI	↓ Fasting Insulin. No change in LDL, HDL, TC	No change in T, SHBG, FAI
Hoegar et al. [69]	RCT	11 (23)	Age = 29.4±5.7 BMI = 39.7±7.1	NIH	Type: N/R Frequency: N/R Intensity: N/R Duration: 48 weeks Supervision: None	Metformin, lifestyle modification plus metformin, or placebo alone	VO_{2peak} not measured ↓ Weight	No change in $AUC_{glucose}$ or $AUC_{insulin}$	No change in T, SHBG, FAI.
Ladson et al. [70]	RCT	59(114)	Age = 28.8 ±4.6 BMI = 38.3±8	NIH	Type: Aerobic Frequency: ≥ 2/week Intensity: N/R Duration: 26 weeks Supervision: Partial	Metformin plus caloric restriction and exercise	No Change in VO_{2peak} ↓ WC	↑ $AUC_{glucose}$, ↑ HDL No change in Fasting glucose, Fasting insulin, $AUC_{insulin}$, cholesterol, LDL	No Change in T, SHBG, FAI, E, LH, FSH
Nybacka et al. [47–49]	RCT (and secondary	Exercise = 17, Diet and	(2011) Age = 31.8±4.9 BMI = 34.9±5.3	Rotterdam	Type: Aerobic (bike or treadmill) Frequency: 2–3/week	Diet only	VO_{2peak} not measured ↓ BMI ↓ Upper body fat	No change in	No change in FAI, T, SHBG, AMH, LH, FSH

Study	Design	Exercise N (total N)	Participant characteristics	PCOS diagnostic criteria	Intervention characteristics	Comparison	Cardiorespiratory and body composition outcomes	Cardio-metabolic outcomes	Hormonal reproductive outcomes
	analysis of RCT)	exercise =12 (43)	(2013) Age = 31.3±4.8 BMI = 34.8±5.2		Intensity: Moderate Duration: 16 weeks Supervision: Full		↓ WC	HOMA, fasting glucose, fasting insulin, ↓ CRP	
Orio et al. [71]	RCT	39 (150)	Age = 25.9±2.7 BMI = 26.7±2.8	NIH	Type: Aerobic (cycling) Frequency: 3/week Intensity: Vigorous (60–70% VO_{2max}) Duration: 26 weeks Supervision: Full	Oral contraceptives	↑ VO_{2peak} ↓ BMI, ↓ W/H ratio	↓ Fasting Insulin, ↓ HOMA, ↓ $AUC_{insulin}$, ↓ TC, ↑ HDL, ↓ LDL No change in $AUC_{glucose}$, Facing glucose	No change in FAI, SHBG, T, E, P, LH, FSH, A, DHEAS
Stener-Victorin et al. [72]	RCT	5 (20)	Age = 30.4 ±5.5 BMI = 26.8±4.8	Rotterdam	Type: Aerobic (walking) Frequency: 3/week Intensity: Light Duration: 16 weeks Supervision: None	Low frequency electroacupuncture or control group	VO_{2peak} not measured ↓ Weight, ↓ BMI	↓ HOMA-IR, ↓ Fasting Insulin No change in Fasting glucose	↑ SHBG, ↑ FAI No change in T
Jedel et al. [73] Stener-Victorin et al. [74]	RCT and Prospective RCT	15 (30)	Age = 30.2 ±4.9 BMI = 27.7±6.4	Rotterdam	Type: Aerobic Frequency: 3/week Intensity: Moderate Duration: 16 weeks Supervision: None	Low frequency electroacupuncture or control group	↑ VO_{2peak} ↓ Weight, ↓ WC, No change in BMI	Not measured	↓ T, ↑ SHBG, ↑ LH, ↑ FSH No change in DHEA
Thomson et al. [43,75]	RCT Secondary analysis of RCT	Diet and aerobic exercise = 18, Diet, and combined exercise =20 (52)	(2008) Age = 29.3 ±6.8 BMI = 36.1 ±4.8 (2016) Age = 30.3 ±6.2 BMI = 36.4±5.6	Rotterdam	Type: Aerobic, or combined aerobic and RT Frequency: 5/week Intensity: Moderate (50–75% of 1RM) Duration: 20 weeks Supervision: N/R	Diet only group	↑ VO_{2peak} ↓ Weight, ↓ WC, ↓ FM, ↓ BF %	↓ Fasting glucose, ↓ Fasting insulin, ↓ HOMA-IR, ↓ BP, ↓ Lipids	↓ T, ↓ FAI, ↑ SHBG
Vigorito et al. [76]	RCT	45 (90)	Age = 21.7±2.3 BMI = 29.3±2.9	Rotterdam	Type: Aerobic Frequency: 3/week Intensity: Vigorous (60–70% VO_{2max}) Duration: 12 weeks Supervision: Full	Usual care with given standard exercise recommendations	↑ VO_{2peak} ↓ WC, ↓ BMI, ↓ W/H ratio	↓ Fasting Insulin, ↓ $AUC_{insulin}$, ↓ $AUC_{glucose}$/$AUC_{insulin}$ ratio, ↓ CRP No change in Fasting glucose, $AUC_{glucose}$	No change in FSH, LH, E, P, T, SHBG, FAI

HIIT high intensity interval training, *RT* resistance training, *HRmax* maximal heart rate, *PCOS* polycystic ovary syndrome, *N/R* not reported, ↑ increase, ↓ decrease, *VO_{2peak}* peak oxygen consumption, *BMI* body mass index, *WC* waist circumference, *W/H* waist to hip ratio, *FM* fat mass, *FFM* fat free mass, *BF %* body fat percentage, *AUC* area under the curve, *HOMA-IR* Homeostatic Model Assessment of Insulin Resistance, *TC* total cholesterol, *HDL* high density lipoproteins, *LDL* low density lipoproteins, *hsCRP* high sensitivity C-reactive protein, *FSH* follicle stimulating hormone, *LH* luteinizing hormone, *SHBG* sex hormone binding globulin, *T* testosterone, *FAI* free androgen index, *P* progesterone, *E* estradiol, *A* androstenedione, *AMH* anti Mullerian hormone, *DHEA* dehydropiandrosterone

Table 3

Summary of exercise and physical activity recommendations in the International Evidence-Based Guidelines for polycystic ovary syndrome (PCOS) [58, 59] (reproduced with permission)

Category	Recommendation	GRADE[a]
CCR	Health professionals should encourage and advise the following for prevention of weight gain and maintenance of health Adults (18–64 years), minimum of 150 min/week of moderate intensity physical activity or 75 min/week of vigorous intensity or an equivalent combination of both; includes muscle-strengthening activities on two non-consecutive days/wk Adolescents, at least 60 min of moderate to vigorous intensity physical activity/day, including those that strengthen muscle and bone at least 3 times weekly Perform activity in at least 10-min bouts or around 1,000 steps, aiming to achieve at least 30 min daily on most days	***
CCR	Health professionals should encourage and advise the following for modest weight loss, prevention of weight-regain and greater health benefits A minimum of 250 min/week of moderate intensity activities or 150 min/week of vigorous intensity or an equivalent combination of both, and muscle-strengthening activities involving major muscle groups on two non-consecutive days/week Minimized sedentary, screen, or sitting time	***
CPP	PCOS is a complex condition with numerous clinical features placing a significant burden on affected women. It is important that exercise and physical activity be included in the treatment plan for women with PCOS and supported by all members of the care team. The significant psychological burden associated with PCOS can impact the success of lifestyle therapy. Therefore, where appropriate referral to a certified professional should be considered as part of a chronic disease management plan. These certified exercise professionals should have a higher education (university) training (likely allied health practitioners) in developing personalized physical activity and formal exercise programs while addressing psychosocial barriers. The certified professionals are likely to be Certified Clinical Exercise Physiologist (ACSM; USA) Accredited Exercise Physiologist (ESSA; Australia) Certified Exercise Practitioner (BASES; UK) Physiotherapist or Physical Therapist (Europe)	N/A
CPP	Fitness instructors/personal trainers should be engaged after confidence and competence is established in exercise programs	N/A
CPP	Fitness devices and technologies could be used as an adjunct to support and promote active lifestyles and minimize sedentary behaviors (step counts and active minutes [79])	N/A

CCR Clinical Consensus Recommendation: In the absence of evidence, a clinical consensus recommendation (i.e. and agreed expert opinion) has been made by our guideline development group, *CPP* Clinical Practice Point: Evidence not sought. A practice point has been made by the guideline development group where important issues arose from discussion of evidence-based or clinical consensus recommendations, *N/A* not applicable

* Conditional recommendation against the option

** Conditional recommendation for either the option or the comparison

*** Conditional recommendation for the option

**** Strong recommendation for the option base GRADE frame work [61]

[a] As these recommendations are consensus statements evidence quality is considered low and no further assessment for quality was undertaken (see [58])