

Relative energy deficiency in dance (RED-D): a consensus method approach to REDs in dance

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ABSTRACT

Relative energy deficiency in sport (REDs) is a potentially severe, challenging, broad-spectrum syndrome with potential negative health and performance outcomes. The numerous research publications and International Olympic Committee consensus statements relating to REDs testify to the challenges faced in early identification or screening, diagnosis and management. Like sport, dance, in its simplest form, can be identified as an activity resulting in physiological energy demands and, as such, requires appropriate energy availability concerning energy expenditures. However, the specificity of physiological and psychological demands in dance must be considered when considering REDs. An environment where physical activity can exceed 30 hours per week and where culture may instil a value that thinness is required puts dancers at increased risk for REDs. The purpose of this study was to provide dance-specific guidance on this complex condition. A RAND/UCLA Delphi Panel method with nominal group technique was used to review the literature from REDs to evaluate how it may relate to dance. In addition to the EP, which was assembled from a multidisciplinary background with expertise in REDs and multiple genres of dance, six focus groups were commissioned. Four of the focus groups were drawn from the EP members and two additional focus groups formed by dancers and artistic leaders. These panels were used to guide the development of a RED-D diagnosis pathway, management plan and risk stratification and return to dance pathway. The dance-specific pathways are designed to be a practical tool for guiding and supporting clinicians managing RED-D. Furthermore, this paper represents an important focus of this area in dance and serves to stimulate discussion and further research within the sector.

in Sport' (REDs) representing this broad-spectrum syndrome.¹⁻³ Dance, like sport, is a generic term and covers multiple genres, all with different physiological and artistic requirements. However, in its simplest definition, dance is a performing art consisting of sequences of movement that require energy availability (EA).⁴⁻¹⁰ In the 2014 IOC statement on REDs, Mountjoy *et al*² detail the evolution of thought from female athlete triad to REDs, defining it as 'an energy deficiency relative to the balance between dietary energy intake and EA required to support homeostasis, health and activities of daily living, growth and sporting activities'. This represents a change in understanding from the original three entities (EA, menstruation and bone health) to the multiple system impact, which also includes but is not limited to decreases in energy metabolism, reproductive function, musculoskeletal health, immunity, glycogen synthesis and cardiovascular and haematological health. The IOC consensus group indicates how these can all individually and synergistically lead to impaired well-being, increased injury risk and decreased sports performance. The increased awareness and research in REDs have led to a further understanding of LEA. Adaptable LEA is associated with benign effects and can be seen as a short-term experience with minimal or no impact on long-term health, well-being or performance. However, problematic LEA is characterised by the duration, magnitude and frequency of LEA and is associated with potentially persistent multi-system impact and maladaptive responses.¹

Due to the complexity of the multi-system impact, the recognition that this can also affect male athletes, and the known psychological and behavioural characteristics associated with REDs, understanding true prevalence may be challenging. It is, therefore, unsurprising that the results of studies on the prevalence of eating disorders are

PURPOSE AND RATIONALE

While 'Female Athlete Triad' was previously used to describe the impact of low energy availability (LEA) in sport,¹ more recently, there has been a growing awareness of the multiple systems affected by LEA and its prevalence in male athletes.²⁻⁵ This increased awareness resulted in the International Olympic Commission (IOC) publishing the original and subsequent updated consensus statements on 'Relative Energy Deficiency



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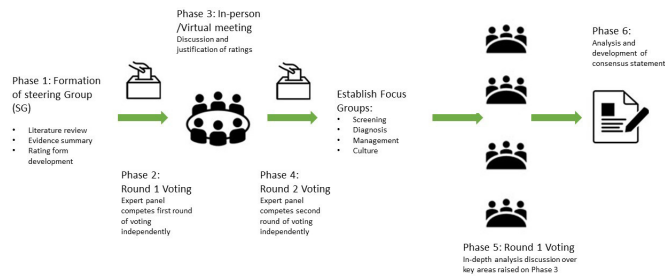


Figure 1 Delphi panel method stages adapted from Broder *et al.*¹⁶

mixed. However, an early study of elite athletes reported a prevalence of clinical and subclinical eating disorders at 13.55% versus a control group of non-athletes at 4.6%.¹¹ Similar figures are reported within a dance population with a 12% overall prevalence of eating disorders and 16.4% specifically in ballet.¹² The data for this study was taken from a meta-analysis of papers published between 1966 and 2013. All relevant dance studies were considered with ballet the largest genre represented (69.7%). The range of studies included professional, non-professional dancers and students (elite and non-elite schools) from studies conducted in Europe, USA, Australia and South Africa. The study concluded that dancers had a three times higher risk of suffering from eating disorders than non-dancers, particularly anorexia nervosa and eating disorder not otherwise specified (EDNOS), and therefore specifically designed services for this population should be considered. Eating disorders are a clinically diagnosed mental illnesses whereby defined criteria characterised by abnormal eating behaviours like self-induced food intake restriction, bingeing or purging are met, whereas disordered eating behaviours include restrictive eating, compulsive eating or irregular eating patterns. Furthermore, disordered eating patterns include excessive exercising to compensate for dietary intake but do not meet the criteria for an eating disorder.¹ As eating disorders represent the more extreme aspect of the LEA continuum, when disordered eating is included, the prevalence in sports rises further, with reports ranging from 0% to 19% in men and from 6% to 45% in women.¹³ No prevalence data currently exists on disordered eating in dance. Dancers with disordered eating also display lower levels of nutritional knowledge, and this may have an impact on body mass index (BMI) where lower BMIs were noted with those with lower nutritional knowledge.¹⁴ Female dance students' eating attitudes and BMI should be monitored during adolescent development.¹⁴

Given the health and performance impacts, there is a duty of care within the dance sector to investigate this further and support dancers affected by relative energy deficiency in dance (RED-D). Furthermore, it is important to establish clear pathways for the prevention, identification and management of RED-D. The purpose of this study was to reach a consensus on the clinical guidelines for identifying and managing RED-D.

METHODS

Methodological considerations were made using the 'Clinical Consensus Manual'.¹⁵ The RAND/UCLA Delphi Panel Method was employed due to its ability to develop clinical guidelines using a process whereby experts would be asked to rate, discuss and then re-rate items established through the literature review.^{16,17} A round of focus group discussions was undertaken, including patient and public involvement (PPI) groups (figure 1).

Steering group

A five-person steering group (SG) undertook the selection and invitation of the EP. The SG represents a sector-wide collaboration that meet weekly since 2020 to discuss and explore solutions to challenging areas in dancers' health and well-being. The SG comprised four clinical directors and one clinical lead from four of the largest professional ballet companies in the UK. Two clinical directors are on the UK's National Institute of Dance Medicine and Science Partners' Group which provide support and clinical services to all genres of dancers based in the UK, including freelance dancers.

Expert panel

Invitation to join the expert panel (EP) was based on the participants' recognised involvement and expertise in REDs and a range of dance genres. Twenty participants were invited to join the EP. All invitees accepted. Participants were selected across several specialities to reflect the expertise needed. These included Sports and Exercise Medicine (4), Endocrinology (2), Rheumatology (1), Psychiatry (1), Psychology (3), Physiology (1), Dietetics (2), and Physiotherapy (6).

Members of the EP were also invited to join specific focus groups: screening (n=4), diagnosis (n=10), risk factors and culture (n=8) and management (n=11), which had separate additional meetings to further explore areas raised as part of the consensus discussions. Two further PPI focus groups represented those affected by RED-D within the dance industry, namely dancers and artistic leaders. There were three dancer focus groups (n=37), comprised of dancers from professional companies across all ranks within the UK as well as representation of freelance dancers from OneDance UK. The artistic leaders (n=5) focus group was made up of artistic directors (4) and a chief executive officer (1) from major UK dance companies.

Delphi questionnaire development

The SG collated information from primary data (policy statements and established care pathways for managing RED-D from the four represented ballet companies) and results from a literature review conducted using PubMed, EMBASE and Sport Discus from June 2012 to June 2022. Medical Subject Headings (MeSH) terms relative energy deficiency in sport, dance, eating disorders, disordered eating were used. Through a series of weekly meetings, the literature was reviewed with key components of REDs

and its impact on health and performance was assimilated. The data was combined into question format and how it may relate to dance in order for it to be interrogated by the EP through the Delphi process. The final questions were agreed on for inclusion in the Delphi questionnaire for voting (online supplemental appendix 1, online supplemental appendix 2). The questionnaire was split into four main areas: questionnaires, diagnosis, management and risk factors.

For the EP Delphi round voting, a rating scale was agreed (strongly agree—5; agree—4; neutral—3; disagree—2; strongly disagree—1). It was also agreed to include an option for ‘out of scope’ to accommodate the scope of the multidisciplinary EP to prevent skewing of data if questions fell outside individual participant’s areas of expertise.

Procedure

In round 1, the EP was asked to rate their level of agreement for each question of the Delphi questionnaire independently. This was followed by an in-person face-to-face meeting (with some panellists attending via video link due to COVID-19 restrictions at the time) to gain further input from all 20 expert panellists. The meeting was co-chaired by a medical doctor and professor in sports medicine and rheumatology with extensive experience in dance medicine (clinical and research) and one of the clinical directors from a major ballet company (physiotherapist). Using the nominal group technique,¹⁸ the meeting chairs reviewed each question and asked panellists to share their reasoning on their ratings and consider the views of others that differed from their own. The meeting chairs rotated the order of EP comments to reduce individual dominance. Using recommendations from the consensus meeting, there was a follow-up Delphi survey of 36 questions. This was used to evaluate consensus on topics from which original consensus was not obtained in the first round of voting. Information gathered from the consensus meeting and two rounds of questionnaires was then distilled into two categories: those questions that reached consensus and those that did not. The focus groups further discussed questions that did not reach a consensus. Additionally, further meetings with the focus groups were used to discuss questions that did not reach a consensus as well as to explore and expand on discussions on various topics like validation of screening tools and creating objective measures for diagnostic criteria.

After completing all the meetings and questionnaires, a summary document comprised the results, findings and recommendations.

Definition and attainment of consensus

It is recognised that consensus of all panellists is unlikely, and the level of consensus can vary from 51% to 80%.¹⁹ Due to the lack of literature pertaining to RED-D, the SG determined the a priori level required for consensus would be 70% agreement. ‘Out of scope’ responses

were eliminated from the calculation. Areas that failed to achieve consensus in the first round of voting were addressed during the face-to-face meeting and subsequent focus group sessions. It was also agreed that consensus values below 70% by the end of the second round of independent voting would constitute non-consensus.

Ethical considerations

To maintain anonymity, the notion of ‘quasi-anonymity’ was applied to independent voting rounds whereby individual panel members did not know the names of participants and the results of individual voting in the EP.

Dissemination and agreement

The final agreed consensus was also distributed to 16 dance medicine experts to achieve international endorsement of the consensus and guidelines. These experts were identified through published literature and the International Association for Dance Medicine and Science. Participants were asked to review the recommendations of the consensus statement including the diagnosis, management and risk stratification and return to dance frameworks. If they agreed with the recommendations, they were asked if they would be prepared to endorse the use of these recommendations. Twelve replied to the request and endorsed the findings and recommendations of the paper.

RESULTS

There was a 100% response rate from the EP to the first and second rounds of questions. At the face-to-face EP meeting, 100% of the EP were in attendance.

Questionnaires

The EP achieved consensus (>70% agreement) on the following areas:

- ▶ Questionnaires play a key role in the diagnosis of RED-D and its management (76%).
- ▶ Questionnaires can play a key role in routine screening (eg, annual) of asymptomatic dancers (88%).
- ▶ Specific questionnaires are useful in supporting a clinical diagnosis in suspected RED-D patients, Low Energy Availability in Females Questionnaire (LEAF-Q) (81%), Low Energy Availability in Males Questionnaire (LEAM-Q) (75%) and Dance-specific Energy Availability Questionnaire (DEAQ) (75%). There was no consensus for the Eating Disorder Examination Questionnaire (EDE-Q) (56%), Female Athlete Screening Tool (FAST) (53%) or Brief Eating Disorders in Athletes Questionnaire (BEDA-Q) (40%).
- ▶ There is consensus that LEAF-Q (75%) and DEAQ (75%) questionnaires are appropriate for routine screening/profiling of dancers to help identify early identification in asymptomatic or unreported RED-D. At the same time, there is no consensus for LEAM-Q (66%), EDE-Q (38%), FAST (53%) and BEDA-Q (33%).

However, in contrast, there is a lack of consensus (29%) regarding the current questionnaires being appropriate for use within the dance population due to issues of validity or specificity.

Diagnosis

There is consensus that:

- ▶ Functional hypothalamic amenorrhoea is present in REDs females (100% consensus)
- ▶ Endocrinological blood tests are effective for understanding potential causes, with ultrasound being considered an effective tool for excluding gynaecological structural causes (83%).
- ▶ Bone biochemistry assessment, including 25-hydroxy-vitamin D, calcium, phosphorus, alkaline phosphatase and albumin, is important after any bone stress injury (92%).
- ▶ Bone mineral density (BMD) assessment, especially dual-energy X-ray absorptiometry (DXA), should be performed after two bone stress injuries (93%) but should be considered after one bone stress injury if there is a high index of suspicion of RED-D (85%).
- ▶ Blood tests play a key role in diagnosing and managing RED-D patients within the dance population (100%).
- ▶ Blood tests are key in routine screening (eg, once or twice a year) of asymptomatic dancers (80%).
- ▶ It is good practice to use blood markers (full blood count (FBC), ferritin, B₁₂, folate, erythrocyte sedimentation rate (ESR), renal function) to screen for nutritional deficiency, low EA and bone health issues once or twice a year in asymptomatic dancers (79%).
- ▶ When considering a differential diagnosis of RED-D, the following blood makers should be considered: FBC, ferritin, B₁₂, folate, ESR, renal function, bone biochemistry (85%).
- ▶ Inadequate quality of sleep (84%) and reduced libido in males (79%) can be associated with RED-D, and enquiring about this can help support a diagnosis of RED-D.
- ▶ Consensus was also reached that dental assessment, looking at oral mucosa, perioral tissue, teeth and periodontal diseases, can be a helpful indicator of an eating disorder in RED-D (92%).
- ▶ Due to a lack of specificity, biomechanical factors, muscle capacity, aerobic capacity and balance assessment cannot be used to support a diagnosis of RED-D (80%).

The following areas did not achieve consensus on whether they could help support a diagnosis of RED-D

- ▶ Daily well-being scores (50%).
- ▶ ECG investigation (33%)
- ▶ Basal metabolic rate assessment (45%).

Management

Regarding nutrition, the EP achieved consensus on

- ▶ Increasing nutritional intake is one of the primary considerations of RED-D management (100%)

- ▶ Evaluating and modifying dance workload is an important consideration in RED-D management (100%)
- ▶ Individual assessment of nutritional requirements relative to energy demands is recommended in RED-D cases (95%)
- ▶ Endocrine (78%) and metabolic (78%) function will correct themselves if the tenets of increased energy intake and managed workload are followed.
- ▶ A liquid meal supplement is not superior to real food when attempting to address energy deficit (70%).

There is a lack of consensus on

- ▶ A balanced liquid nutritional supplement with appropriate expertise from a doctor or dietitian can be an effective tool in increasing total nutritional intake in a dance population (21%).
- ▶ Leptin is an appropriate and efficacious way of restoring appetite (50%).

Regarding bone health, the EP achieved consensus on the use of

- ▶ Structured resistance training as an effective strategy to promote good bone health (100%)
- ▶ Vitamin D supplementation of 1000–2000 international units (IU)/day (or equivalent) is the best daily dose to maintain vitamin D levels in the blood (100%).

There is a lack of consensus on the use of

- ▶ Bisphosphonates under the guidance of a specialist as an efficacious way of restoring bone structure in selective cases (males 67%; females 44%)
- ▶ Insulin-like growth factor 1 is an appropriate way of restoring bone structure (43%).

With regard to management of RED-D in female patients, the EP achieved consensus on

- ▶ Increasing EA is fundamental to restoring a normal menstrual cycle in RED-D (83%).
- ▶ The contraceptive pill should not be considered in the management of RED-D (70%)
- ▶ In some cases, transdermal oestradiol therapy with cyclic oral progestin is an efficacious management strategy for restoring normal bone health (90%).

Risk factors

The EP achieved consensus on the following statements:

There is consensus (100%) that the risk management table outlined in the IOC consensus update¹ could benefit from adaptation for use in dance. Additionally, there is consensus (100%) that the decision-making process outlined in the IOC consensus update²⁰ could benefit from adaptation for use in dance. Additional questions were posed to the EP, reflecting some of the perceived risks specific to dance. Primarily, the panel felt that there is a lack of understanding that RED-D is a risk factor in dance (94%). The culture built on aesthetics (94%) and high workload (94%) added to the risk factors, as did under-fuelling (100%) and skipping meals (82%).

The EP agreed that every dance company or school should have a RED-D audit and action plan aimed at



proactively addressing established risk factors within a dance environment as well as an internal education curriculum which aligns with the current IOC view that education is one of the most important interventional strategies for REDs.^{1 21} This was accompanied by consensus that every dance company or school should have a management and referral pathway, including an emergency action plan.

Focus groups

The format of the questionnaire, diagnosis and management focus groups constituted a group discussion based on themes emerging from the Delphi questionnaires and were made up of members from the EP with special interest in the specific topics.

The questionnaire focus group continued to explore the challenges of questionnaires regarding their validity. The outcomes from the group were a call for further research to provide a valid and appropriate system for early identification of RED-D.

The diagnosis focus group agreed on the use of gynaecological ultrasound for the exclusion of primary ovarian pathology as a cause of amenorrhoea and that this should include an understanding of the difference between multicystic ovarian changes and polycystic ovarian disease.

Additionally, they advocated the use of BMD assessment for patients with a single bone stress injury in those that demonstrate a high index of suspicion of RED-D. A high index of suspicion was defined as a fracture sustained with trivial trauma, amenorrhoea lasting greater than 3 months, a history of a negative relationship with food or a BMI below 20. The diagnosis focus group discussed the value of a RED-D Diagnosis Pathway for RED-D that supports a decision-making process derived from primary and secondary criteria (figure 2).

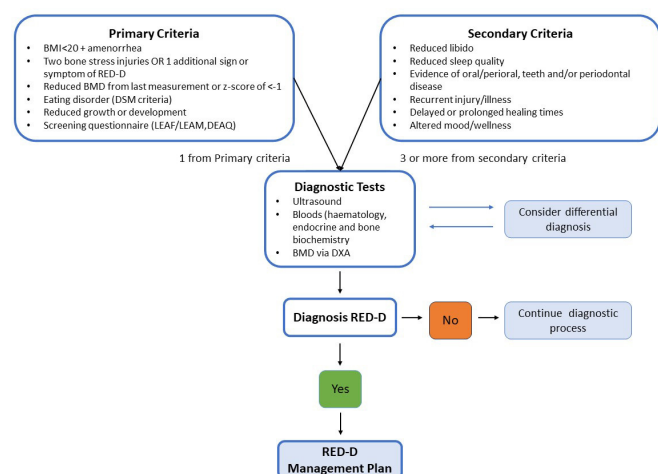


Figure 2 RED-D diagnosis pathway. BMD, bone mineral density; BMI, body mass index; DEAQ, Dance-specific Energy Availability Questionnaire; DXA, dual-energy X-ray absorptiometry; LEAF, Low Energy Availability in Females; LEAM, Low Energy Availability in Males; RED-D, relative energy deficiency in dance.

The management focus group discussed pathways in three key areas: risk assessment and return-to-dance, RED-D management for schools and companies, and vitamin D's role in RED-D management.

This group identified the importance of the multidisciplinary team (MDT) in the management of RED-D for both the RED-D management pathway (figure 3) and the risk stratification and return to dance pathway. However, it also acknowledged that many dancers work freelance, so access to MDT support may be limited. Models for both were proposed.

In relation to vitamin D, the importance of this therapy was acknowledged, but the risk of toxicity was of concern. Therefore, the need for regular monitoring was advocated, with twice yearly monitoring agreed and a potential starter dose between 1000 and 2000 IU or equivalent suggested.

The dancers focus group noted that there was great variation in the quality and consistency of education on the topic of RED-D within the numerous ballet schools worldwide. In some instances, maladaptive behaviours (eg, restrictive eating) were rewarded with praise, roles and jobs. Culture plays a significant role in developing and managing RED-D within the ballet industry. Scheduling, both on a micro (daily) and macro (season) level, was highlighted as a consistent challenge. Little periodisation exists within a dance company's performance season, and there are often limited opportunities to fuel adequately during a rehearsal or performance day. Nutrition availability and cost were additional challenges when on tour. The role of aesthetics in dance (specifically ballet) is one area that, if not managed correctly, can be a driver to developing RED-D. The role society plays in this area was also highlighted. The dancers acknowledged that they understood the risk that amenorrhoea poses to health but also acknowledged that dancers often are untruthful when questioned on the topic.

The leadership focus group, containing chief executive officers and artistic directors from several UK-based ballet companies, discussed a series of questions surrounding the risk of RED-D, including aesthetic demands of the artform, scheduling of workload, culture of under fuelling and potential challenges to reporting and management of RED-D. The leadership group acknowledged that RED-D presented a risk to individuals, companies and the wider dance sector. There was uncertainty around the management of RED-D, particularly concerning culture. They agreed that standards of excellence in professional ballet are changing, moving from the aesthetic to a 'performance ready' approach and that a process for managing safe conversations on aesthetics is required. Scheduling, both on a micro (daily) and a macro (season) level, was highlighted as a consistent challenge for the leadership group and was a point of shared concern with the dancer focus group. These two focus groups also shared concerns about both the financial and the nutrition availability barriers that faced dancers when on tour. The leadership group highlighted that education on RED-D

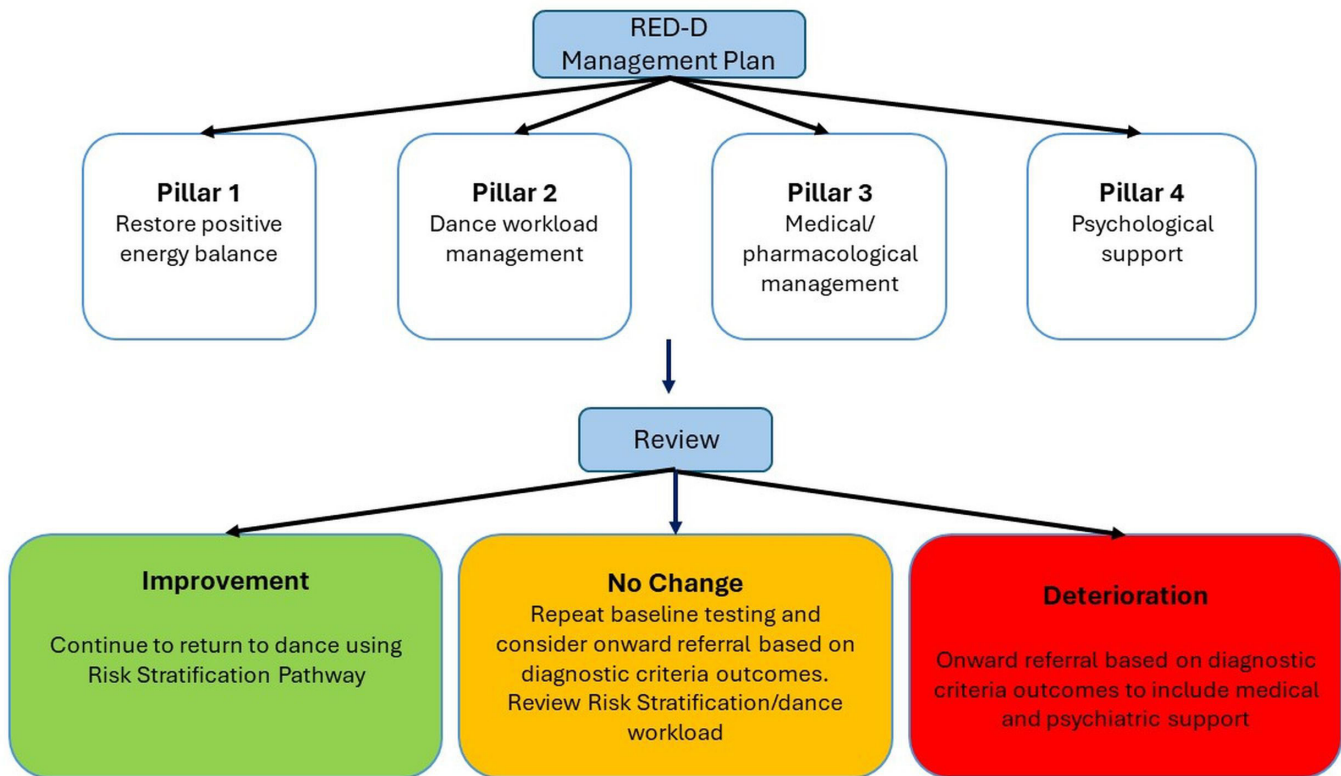


Figure 3 RED-D management pathway. RED-D, relative energy deficiency in dance.

was necessary for the developing dancer (at school age) but did not indicate a need for education at the artistic leadership level.

Dissemination and endorsement

The consensus outcomes were distributed to 16 international dance medicine organisations and dance companies. Included in the invitations were larger ballet companies as they typically have in-house medical teams able to evaluate the consensus statement as well as national organisations that support the full range of dance genres. We received 14 responses, and they all endorsed the consensus and management plans: International Association for Dance Medicine and Science, Performing Arts Medicine Association, National Institute for Dance Medicine and Science (UK), L'Association Danse Médecine Recherche (France), Gemeinnütziger Verein für Tanzmedizin (Germany), Berlin Dance Institute (Germany), Australian Ballet Company, Dutch National Ballet Company, Finnish National Ballet Company, Royal Danish Ballet, Swedish Royal Ballet Company, Opera National de Paris (France), Dance Health Finland, Healthy Dancer Canada.

DISCUSSION

The purpose of this study was to review previously published work on REDs and create a consensus statement on the screening, diagnosis, risk factors, culture and management of RED-D and to provide dance-specific guidance on this complex condition.

REDs is a syndrome with a complex presentation and, therefore, can be a challenge to diagnose.^{3 22} REDs can affect multiple systems and are often considered a diagnosis by excluding alternative causes due to the lack of objective specificity required for a diagnosis. The IOC recognises both the health and the performance consequences of REDs.^{1 2} Health consequences include impaired reproductive function, impaired bone health, haematological effects, impaired growth and development, psychological disorders, impaired cardiovascular function, impaired neurocognitive function, urinary incontinence, sleep disturbance, reduced skeletal muscle function, glucose and lipid metabolism, impaired energy metabolism, gastrointestinal and immunological effects.¹ Performance consequences include decreased athlete availability, decreased training response, decreased recovery, decreased cognitive performance skill, decreased motivation, decreased muscle strength, decreased endurance performance and decreased power performance.¹ These consequences were assimilated into the questions posed to the EP.

Questionnaires

Questionnaires to support diagnoses are well utilised for many medical conditions, including LEA and REDs.^{23 24} While the EP reached consensus over the usefulness of questionnaires in supporting a diagnosis of RED-D or as an early identification tool, the panel failed to reach consensus over the questionnaires' validity and specificity. The questionnaires advocated were the LEAF-Q,

LEAM-Q and DEAQ. The LEAF-Q has been used for several years and was designed to identify athletes at risk of the female athlete triad. This was done by evaluating injuries, gastrointestinal and reproductive function to assess the health consequences seen in the triad and to be used to complement validated disordered eating instruments.²⁵ The evolution from female athlete triad to REDs was partly influenced by the need to include male athletes. The LEAM-Q introduced a measure to accommodate male athletes. As part of the validation process, Lundy *et al*²⁶ constructed a screening tool that evaluated dizziness, thermoregulation, gastrointestinal symptoms, injury, illness, well-being, recovery, sleep and sex drive. The outcomes of their study saw scores for sleep and thermoregulation excluded as they failed to be associated with any clinical markers. At the same time, dizziness, illness, fatigue and sex drive demonstrated sufficient sensitivity to be retained in the questionnaire. Low sex drive was identified as the most effective self-reported symptom in identifying male athletes with potential LEA.²⁶ The extensive validation process included athletes from various countries and ethnicities, ranging from sub-elite to elite and across several endurance and weight-sensitive sports. Still, it did not assess the use of dancers. The DEAQ has the LEAF-Q at its foundation but builds on the specificity often needed when considering the dance population²⁷; it is currently undergoing a validation process.

As reported in sport,²⁸ a further factor affecting the efficacy of questionnaires to support a diagnosis of RED-D may be social desirability bias, where respondents answer questions based on how they will be interpreted rather than providing an honest answer.²⁹ Dancers who intentionally reduce energy intake may not want to disclose these actions or the impact on their bodies. For example, the absence of a menstrual cycle mentioned in a questionnaire may potentially risk being withdrawn from dance-related activities. Psychological safety is defined as ‘...environments where athletes are comfortable being themselves, can take necessary interpersonal risks, have the knowledge and understanding of mental health symptoms and disorders, and feel supported and comfortable in seeking help if needed’.³⁰ Discussion among the EP, dancers and leadership focus groups suggests that there may be a low level of psychological safety in the dance sector when relating to RED-D, which has been reflected in recent research exploring dancers attitudes to injury.^{31 32} To improve the validity of the RED-D questionnaires, work to enhance psychological safety will need to occur. In addition to validity issues, the EP also discussed the usability of questionnaires and reference was made to the length of the questionnaire as well as the lack of psychological assessment in the questionnaires discussed. Further work is needed to produce a valid, specific, inclusive questionnaire for both sexes that is time-efficient for use in the dance sector.

Diagnosis

Menstrual and endocrine dysfunction are listed as health consequences of REDs¹ with functional hypothalamic amenorrhoea (FHA) being associated with disordered eating and LEA.³³ Therefore, reduced frequency or absence of a menstrual cycle was agreed to be a key indicator of RED-D in female dancers. It was determined that the use of gynaecological ultrasound was needed to exclude other potential causes of amenorrhoea and should be used in cases of primary amenorrhoea and in secondary amenorrhoea to exclude potential structural causes. EA of less than 125 kJ/kg fat-free mass has been linked to suppression of gonadotropin-releasing hormones (luteal hormone and follicle-stimulating hormone) and impaired thyroid function³⁴ with reduced triiodothyronine (T3) and thyroxine (T4) and normal or low thyroid-stimulating hormone seen in athletes with FHA.²⁵ There was strong consensus from the EP on using endocrine blood tests to screen and diagnose RED-D. Limitations to the use of endocrine blood profiles include female patients receiving oestrogen/progestogen supplementation through a contraceptive pill, so there continues to be a need for multi-system evaluation in the diagnosis of RED-D.

Bone health was part of the original triad³⁵ and was important in REDs.¹ Alongside endocrine profiles, the EP advocated blood tests to assess bone health in the presence of a bone stress injury. This included an FBC, inflammatory markers, bone biochemistry including vitamin D and parathyroid hormone and renal function. The use of bone biochemistry is an addition to the recommendations from the IOC consensus statements. Dancers are reported to have a high prevalence of low BMD, with one study reporting 52% of 151 elite and pre-elite dancers.^{36 37} This is accompanied by the ‘ideal’ dance body aesthetic, particularly in ballet, having an increased predisposition of having genetic variants linked to low BMD probability.³⁸ With the increased prevalence of low BMD, the higher level of exposure in dance potentially being greater than 30 hours per week and low vitamin D levels³⁹ it is important to evaluate bone health in dancers suspected of RED-D.

Measurement of BMD was also advocated in the presence of bone stress injuries. The EP agreed that BMD should be measured in patients with a history of two bone stress injuries but could be considered after only one injury if there was a high index of suspicion of the diagnosis of RED-D. DXA scanning was agreed to be the best technique to measure BMD, and it can be extended further to include a measure of body composition in support of a diagnosis of RED-D.

The EP agreed that other health and performance consequences were useful to support a diagnosis of RED-D. However, it was acknowledged that the threshold for reporting risk in these may be difficult and require further research to help determine their sensitivity in RED-D. This applies to the quality of sleep or reduced libido. Furthermore, it was acknowledged that some may



require more specialist input, like dental evaluations. Although linked to the health and performance consequences,¹ injury, biomechanical factors, muscle capacity, aerobic capacity or balance assessment were considered to lack specificity in dance where insufficient data on norms exist. Similarly, there was no consensus on whether daily well-being scores or ECGs could support a diagnosis of RED-D. The ratio between resting metabolic rate (RMR), representing the cost of basic physiological function, and predicted RMR has been reported to be lower in dancers associated with lower EA⁴⁰ but the assessment of RMR outside of the laboratory settings is challenging.¹ Staal *et al*²³ demonstrated some encouraging results when exploring low RMR ratios (RMRr) as a surrogate marker for energy deficiency in male and female ballet dancers. However, the authors acknowledged a range of challenges to the interpretation of results, including the use of hormonal contraceptives and ratio thresholds for the interpretation of risk in RMRr. With further work needed, there was no consensus among the EP on whether RMRr would be a useful indicator in RED-D.

In conjunction with the diagnosis focus group, a diagnosis pathway was established (figure 2).

Criteria were based on the health and performance impacts of REDs.¹ Primary criteria were those markers that achieved consensus with the EP. Secondary criteria were those that failed to achieve consensus or were considered to lack specificity or objectivity in dance to support a diagnosis of RED-D in isolation, but if a patient presented with three or more, it would warrant RED-D investigations. The diagnosis framework reflects some components of the updated IOC REDs CAT2 and provides a simple flow chart for clinicians assessing dancers suspected of RED-D. For a more detailed and validated tool, we would advocate incorporating the updated IOC REDs CAT2 tool.⁴¹

Management

The diagnostic process and the identification of health and performance consequences play an important role in the direction of management for RED-D patients. A challenge for the management is establishing the origins of problematic LEA, intentional or unintentional. Unintentional may result from a failure to understand the energy requirements of the dancing training. This may be particularly challenging in dance as there can be marked variations in the physiological demands and energy requirements of different casts, let alone different repertoires. Dietary restraint may be intentional in an environment where the aesthetic is perceived as a major factor in casting. Intentional origin may also include the presence of underlying disordered eating or eating disorders and mental health issues. The multifactorial nature of the presentation supports the need for a multifactorial, multidisciplinary approach to management. A four-pillar approach to RED-D management was proposed (figure 3).

In recognising the health impact of RED-D, the EP agreed that endocrine and metabolic dysfunction and amenorrhoea can be corrected by increasing nutritional intake and modifying dance workload, an approach reflected in the updated IOC statement.¹ The dietician is important in designing a strategy for increasing intake in this aesthetically demanding environment. The EP agreed that liquid supplementation did not improve nutritional intake compared with solid food in addressing RED-D.

A reported health and performance consequence of LEA is diminished bone health and the risk of bone stress injuries. In an early study, Kadel *et al*⁴² reported 27 fractures in 17 dancers from a sample of 54 female dancers. Kadel goes on to report that the stress fracture group had a significantly longer period of amenorrhoea than those with no stress fractures. When managing bone stress injuries in dance, an underlying cause of RED-D needs to be considered. It was agreed that the use of oral contraception should not be considered as part of the management strategy but that the use of transdermal oestradiol therapy with cyclic oral progestin is an efficacious management strategy in restoring normal bone health in some cases, which reflects guidance from the latest IOC consensus.¹ Furthermore, it was agreed that vitamin D supplementation of 1000–2000 IU/day (or equivalent) is the best daily dose to maintain vitamin D levels in the blood. There is a high prevalence of low vitamin D levels in dancers³⁹ so vigilance is needed. There was no consensus regarding additional management of bone health using bisphosphonates and the growing number of new bone protective medications, and a recognition that further research is needed in this area.

Workload management was seen as an effective management strategy for RED-D. The nature of the dance workload can be variable. Research into dance's physiological demands has demonstrated that the art form is highly skilled and that physiological loading can vary significantly based on genre and repertoire.^{43 44} Careful evaluation of workload is an important aspect of RED-D management that must balance the energy expenditure against the psychological impact of withdrawal from dance-related activities. Working closely with dance management artistic staff and the wider MDT, a clear, and where possible, objectively measured workload strategy needs to be established with scope for monitoring and regular review.

Focus groups

Adding focus groups to the Delphi process created a useful opportunity to reflect and develop themes that emerged from the voting and discussion rounds.

The questionnaire focus group acknowledged that questionnaires can be valuable but highlighted the lack of validated questionnaires in dance complicated by the potential of untruthful responses. Therefore, it was felt that more work is needed to explore whether questionnaires can provide a valuable adjunct to early identification of RED-D.

The diagnosis focus group expanded on the complexity and challenge of diagnosing RED-D. One area of discussion was intentional versus unintentional LEA. With unintentional LEA, the group recognised that patients might be more forthcoming with the history and symptom reporting. At the same time, with intentional LEA, it was felt that objective markers might assist in diagnosing RED-D where the patient may not volunteer information, like the absence of a menstrual cycle, for fear of repercussions. While it was already recognised that gynaecological ultrasound is indicated in primary amenorrhoea, according to the National Institute for Health and Care Excellence guidelines,⁴⁵ it was agreed that it could be considered in cases of secondary amenorrhoea to exclude structural causes, in particular distinguishing between the presence of multicystic versus polycystic ovaries. Similarly, it has been advocated that a BMD evaluation is indicated after two bone stress injuries. The focus group agreed that in cases where a high index of suspicion existed, namely due to a BMI less than 20 and amenorrhoea for at least 3 months, a bone mineral evaluation would be warranted. It was recognised that some data, such as ‘increased injuries’ associated with REDs¹ could be considered ‘objective’ data. Still, due to a lack of specificity and normative values in dance, it would be insufficient to be used in isolation to diagnose RED-D. Furthermore, evaluating mental health status, including well-being, mood and sleep, was recognised as important but still subject to variability in their interpretation in relation to RED-D if other criteria were absent. While the IOC identified low libido in males in their latest consensus as an emerging indicator or REDs,¹ the focus group expressed similar views in relation to libido as mood and sleep due to the challenge of interpretation. The use of a diagnostic framework based on primary criteria that immediately trigger investigations for RED-D and secondary criteria that may have different weighting, but any three criteria could be used to instigate a diagnostic process (figure 2) represents a starting point from which further research and evaluation can help determine its sensitivity in detecting RED-D.

Risk stratification and return-to-dance pathways are proposed to support decision-making in the dance. In their latest statement, the IOC proposes a differentiation between adaptable LEA and problematic EA, with the latter linked to health and performance challenges. Furthermore, they discuss the evolution of humans to be

physically active, but not their ability to tolerate modern elite sports training, especially in endurance sports where training may exceed 30 hours per week. A typical professional dancer in ballet will be contracted to 30 hours of dance-related activity a week without accounting for additional strength or fitness training.¹ Furthermore, the variability in workload with different intensities experienced with different roles within the same repertoire can make appropriate energy intake relative to workload challenging. An individualised approach to patient management working within the framework will allow dancers to be supported.

The goal of the PPI focus groups was to use pre-determined questions and open discussion to establish the level of understanding that the dancers and artistic leaders have on RED-D and gain insight into attitudes, beliefs and behaviours that may act as drivers of the condition. Within the dancers’ focus group, several themes were identified: education at school, the role of culture and understanding amenorrhoea. Dancers’ perceptions of the aesthetic required for dance appear at odds with the requirements expressed by the artistic leaders whose language focused on energy and artistic delivery as opposed to body shape. Whether this disparity is historical or a representation of vulnerability in the sector where the perceived risk of not being employed or cast due to body shape needs further evaluation. Identifying and analysing these shared themes play a key role in disseminating the findings of this consensus statement. Further output may include best practice guidelines, such as fuelling through rehearsal, performance days, and week and load periodisation through a season. Additional considerations should include education resources and agreed codes of conduct.

In developing risk stratification and a return to dance pathway, it was important to acknowledge the importance of load management in RED-D while balancing the psychological impact of withdrawal (or inclusion) in dance-related activities. Dance Injury and Availability Classification (figure 4) is currently used at the four major dance companies in the SG.

This classification system had been adapted from the IOC injury surveillance consensus statement⁴⁶ and represented a format already familiar within the sector. Therefore, it was proposed to use the same classification format for RED-D for risk stratification and return to dance (figure 5).

Dance intensity and workload can vary between repertoires, and it is advised that a knowledgeable person that has an understanding of RED-D advises on the load intensity of dance-related activity to better appreciate the potential risk of continued performance.

Risk factors

The EP recognised the value of the IOC risk management plan but also acknowledged that dance may have some institutional risk factors associated with culture and beliefs within dance, including perceptions of aesthetic

Status (injury)	Time loss (TL)/ Non-time loss (NTL)	Definition	Explanation/ example
FULLY ON (Green)	NTL	No injury/illness, able to perform	Full activity in Class/Rehearsal/Performance
FULLY ON with PATHOLOGY (Yellow)	NTL	Pathology present but able to perform	Modified Class/Rehearsal. Could perform if suitable
MODIFIED with PATHOLOGY (Orange)	TL	Pathology present but not able to perform	Modified Class/Rehearsal. No Performance
FULLY OFF (Red)	TL	Injured, not able to perform	No Class/Rehearsal/Performance

Figure 4 Dance injury and availability classification.

Status (injury)	Time loss (TL)/ Non-time loss (NTL)	Definition	Explanation/ example
FULLY ON (Green)	NTL	No or very low suspicion of RED-D	Full activity in Class/Rehearsal/ Performance
FULLY ON with PATHOLOGY (Yellow)	NTL	Suspicion or confirmation of RED-D	Modified Class/Rehearsal. Could Perform if suitable
MODIFIED with PATHOLOGY (Orange)	TL	Confirmed RED-D, health and/or performance risk	Modified Class/Rehearsal. No Performance
FULLY OFF (Red)	TL	Confirmed RED-D, health and/or performance risk, severe or deteriorating	No Class/ No Rehearsal/ No Performance

Figure 5 Risk stratification and return to dance pathway.

requirements, further clarified through the PPI focus groups. It was recommended that work be developed on education on the causes and risks of RED-D and that vocational schools be an important target of messaging. With the results of the stakeholder focus groups, it was clear that an educational drive on RED-D is needed for dancers and all those working with them and that collaborative thinking at all levels is required to impact the risks of RED-D. The EP also recognised the need for better mental health support. This need has also been reflected in the updated IOC consensus statements.¹ Any management plan for addressing RED-D should seek the input of a mental health professional as part of the multidisciplinary approach. It was also acknowledged that there has been a positive trend in research and understanding of REDs and that policies relating to RED-D would need to be updated as understanding grows. It was agreed the SG would evaluate the best practice and emerging evidence on a 2 yearly basis and any updates agreed and disseminated.

LIMITATIONS

The construction of the EP was undertaken by an SG. While the SG selected the panel based on their known expertise in both REDs and dance, the exclusion of potential contributors from exclusively sports backgrounds to the EP needs to be considered. As is the case in the IOC REDs consensus that offers an umbrella strategy for 'sport', this paper set out to offer a basis for the identification and management of RED-D for all dance genres. Participants in the EP have experience across all genres of dance; however, ballet remained the greatest collective experience. While RED-D might have a greater prevalence in ballet as opposed to other genres, more work is needed to determine this and if genre-specific differences need to be considered. As part of a strategy to include a multidisciplinary EP to allow for cross-fertilisation of views and ideas, an option to 'opt-out' of answers to questions based on the scope of practice/expertise resulted in reduced numbers contributing to certain questions.

CONCLUSIONS

RED-D, like REDs, represents a complex, multi-system disorder. The need for early identification and clear

management strategies is evident. Using a rigorous consensus methodology, we are able to provide clear pathways for the diagnosis, management and risk stratification and return to dance for patients with RED-D. The diagnosis pathway recognises primary criteria within the diagnosis process but also acknowledges where secondary criteria that lack of sensitivity may be used to support a decision to investigate a RED-D. The management pathway reflects the wide physiological and psychological impact of RED-D and demonstrates the need for a multidisciplinary approach in its management, importantly including psychological input. The use of the risk stratification and return to dance pathway allows those in the dance sector working with RED-D to apply a dance-specific graduated approach to safely support dancers returning to full dance.

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REFERENCES

- Mountjoy M, Ackerman KE, Bailey DM, *et al*. International Olympic Committee's (IOC) consensus statement on relative energy deficiency in sport (Reds). *Br J Sports Med* 2023;57:1073–97.
- Mountjoy M, Sundgot-Borgen J, Burke L, *et al*. The IOC consensus statement: beyond the female athlete Triad—relative energy deficiency in sport (RED-S). *Br J Sports Med* 2014;48:491–7.
- Mountjoy M, Sundgot-Borgen JK, Burke LM, *et al*. IOC consensus statement on relative energy deficiency in sport (RED-S): 2018 update. *Br J Sports Med* 2018;52:687–97.
- Koutedakis Y, Jamurtas A. The dancer as a performing athlete: physiological considerations. *Sports Med* 2004;34:651–61.
- Prates CM, Tsiouti N, Fagundes A de O, *et al*. Hip hop party dance: cardiorespiratory profile and responses to a predefined sequence. *J Dance Med Sci* 2023;27:41–9.
- Rodrigues-Krause J, dos Santos Cunha G, Alberton CL, *et al*. Oxygen consumption and heart rate responses to isolated ballet exercise SETS. *J Dance Med Sci* 2014;18:99–105.
- Schantz PG, Astrand PO. Physiological characteristics of classical ballet. *Med Sci Sports Exerc* 1984;16:472–6.
- Stephens N, Wyon M. Physiological characteristics of musical theatre performers and the effect on cardiorespiratory demand whilst singing and dancing. *Med Probl Perform Art* 2020;35:54–8.
- Wyon MA, Abt G, Redding E, *et al*. Oxygen uptake during of modern dance class, rehearsal and performance. *J Strength Cond Res* 2004;18:646–9.
- Wyon MA, Harris J, Adams F, *et al*. Cardiorespiratory profile and performance demands of elite hip-hop dancers: breaking and new style. *Med Probl Perform Art* 2018;33:198–204.
- Torstveit MK, Sundgot-Borgen J. The female athlete Triad: are elite athletes at increased risk? *Med Sci Sports Exerc* 2005;37:184–93.
- Arcelus J, Witcomb GL, Mitchell A. Prevalence of eating disorders amongst dancers: a systemic review and meta-analysis. *Eur Eat Disord Rev* 2014;22:92–101.
- Bratland-Sanda S, Sundgot-Borgen J. Eating disorders in athletes: overview of prevalence, risk factors and recommendations for prevention and treatment. *Eur J Sport Sci* 2013;13:499–508.
- Wyon MA, Hutchings KM, Wells A, *et al*. Body mass index, nutritional knowledge, and eating behaviors in elite student and professional ballet dancers. *Clin J Sport Med* 2014;24:390–6.
- Rosenfeld RM, Nnacheta LC, Corrigan MD. Clinical consensus statement development manual. *Otolaryngol Head Neck Surg* 2015;153(2 Suppl):S1–14.
- Broder MS, Gibbs SN, Yermilov I. An adaptation of the RAND/UCLA modified Delphi panel method in the time of COVID-19. *J Healthc Leadersh* 2022;14:63–70.
- Okoli C, Pawlowski SD. The Delphi method as a research tool: an example, design considerations and applications. *Inf Manag* 2004;42:15–29.
- Nair R, Aggarwal R, Khanna D. Methods of formal consensus in classification/diagnostic criteria and guideline development. *Semin Arthritis Rheum* 2011;41:95–105.
- Chuenjitwongsa S, Poolthong S, Bullock A, *et al*. Developing common competencies for Southeast Asian general dental practitioners. *J Dent Educ* 2017;81:1114–23.
- Stellingwerff T, Mountjoy M, McCluskey WT, *et al*. Review of the scientific rationale, development and validation of the International Olympic committee relative energy deficiency in sport clinical assessment tool: V. 2 (IOC Reds Cat2)—By a subgroup of the IOC consensus on Reds. *Br J Sports Med* 2023;57:1109–18.
- Torstveit MK, Rosenvinge JH, Sundgot-Borgen J. Prevalence of eating disorders and the predictive power of risk models in female elite athletes: a controlled study. *Scand J Med Sci Sports* 2008;18:108–18.
- Robertson S, Mountjoy M. A review of prevention, diagnosis, and treatment of relative energy deficiency in sport in artistic (synchronized) swimming. *Int J Sport Nutr Exerc Metab* 2018;28:375–84.
- Staal S, Sjödin A, Fahrenholtz I, *et al*. Low Rmrratio as a surrogate marker for energy deficiency, the choice of predictive equation vital for correctly identifying male and female ballet dancers at risk. *Int J Sport Nutr Exerc Metab* 2018;28:412–8.
- Sim A, Burns SF. Questionnaires as measures for low energy availability (LEA) and relative energy deficiency in sport (RED-S) in athletes. *J Eat Disord* 2021;9:41.
- Melin A, Tornberg AB, Skouby S, *et al*. The LEAF questionnaire: a screening tool for the identification of female athletes at risk for the female athlete Triad. *Br J Sports Med* 2014;48:540–5.
- Lundy B, Torstveit MK, Stenqvist TB, *et al*. Screening for low energy availability in male athletes: attempted validation of LEAM-Q. *Nutrients* 2022;14:1873.
- Keay N, Overseas A, Francis G. Indicators and correlates of low energy availability in male and female dancers. *BMJ Open Sport Exerc Med* 2020;6:e000906.
- Rice S, Walton CC, Pilkington V, *et al*. Psychological safety in elite sport settings: a psychometric study of the sport psychological safety inventory. *BMJ Open Sport Exerc Med* 2022;8:e001251.
- Martinsen M, Sundgot-Borgen J. Higher prevalence of eating disorders among adolescent elite athletes than controls. *Med Sci Sports Exerc* 2013;45:1188–97.
- Currie A, Blauwet C, Bindra A, *et al*. Athlete mental health: future directions. *Br J Sports Med* 2021;55:1243–4.
- Paglione V, Kenny SJ, Bridel W, *et al*. I guess you just have to deal with it': pre-professional ballet dancers' experiences of pain, injury, and social support. *Res Dance Educ* 2023;1:23.
- Soundy A, Lim JY. Pain perceptions, suffering and pain behaviours of professional and pre-professional dancers towards pain and injury: a qualitative review. *Behav Sci (Basel)* 2023;13:268.
- Sundgot-Borgen J, Torstveit MK. The female football player, disordered eating, menstrual function and bone health. *Br J Sports Med* 2007;41 Suppl 1(Suppl 1):i68–72.
- Loucks AB, Thuma JR. Luteinizing hormone pulsatility is disrupted at a threshold of energy availability in regularly menstruating women. *J Clin Endocrinol Metab* 2003;88:297–311.
- Nattiv A, Loucks A, Manore M. n.d. The female athlete Triad: position stand. *Med Sci Sports Exerc*;2007:1867–81.
- Hincapié CA, Cassidy JD. Disordered eating, menstrual disturbances, and low bone mineral density in dancers: a systematic review. *Arch Phys Med Rehabil* 2010;91:1777–1789.
- Amorim T, Koutedakis Y, Nevill A, *et al*. Bone mineral density in vocational and professional ballet dancers. *Osteoporos Int* 2017;28:2903–12.
- Amorim T, Durães C, Machado JC, *et al*. Genetic variation in WNT/β-catenin and ER signalling pathways in female and male elite dancers and its associations with low bone mineral density: a cross-section and longitudinal study. *Osteoporos Int* 2018;29:2261–74.
- Wolman R, Wyon M, Allen N, *et al*. The vitamin D status of professional dancers in the winter and in the summer. *J Sci Med Sport* 2013;16:388–91.
- Doyle-Lucas AF, Davy BM. Development and evaluation of an educational intervention program for pre-professional adolescent ballet dancers: nutrition for optimal performance. *J Dance Med Sci* 2011;15:65–75.



- 41 Stellingwerff T, Morton JP, Burke LM. A framework for periodized nutrition for athletics. *Int J Sport Nutr Exerc Metab* 2019;29:141–51.
- 42 Kadel NJ, Teitz CC, Kronmal RA. Stress fractures in ballet dancers. *Am J Sports Med* 1992;20:445–9.
- 43 Kozai AC, Twitchett E, Morgan S, *et al*. Workload intensity and rest periods in professional ballet: connotations for injury. *Int J Sports Med* 2020;41:373–9.
- 44 Shaw JW, Mattiussi AM, Brown DD, *et al*. Dance exposure, individual characteristics, and injury risk over five seasons in a professional ballet company. *Med Sci Sports Exerc* 2021;53:2290–7.
- 45 Wilson GT, Shafran R. Eating disorders guidelines from NICE. *Lancet* 2005;365:79–81.
- 46 Bahr R, Clarsen B, Derman W, *et al*. International Olympic committee consensus statement: methods for recording and reporting of epidemiological data on injury and illness in sports 2020 (including the STROBE extension for sports injury and illness surveillance (STROBE-SIIS)). *Orthop J Sports Med* 2020;8:2325967120902908.