Review

Conditioning Methodologies for DanceSport

Lessons from Gymnastics, Figure Skating, and Concert Dance Research

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OBJECTIVES: Dancesport, the competitive branch of ballroom dancing, places high physiological and psychological demands on its practitioners, but pedagogical resources in these areas for this dance form are limited. Dancesport competitors could benefit from strategies used in other aesthetic sports. In this review, we identify conditioning methodologies from gymnastics, figure skating, and contemporary, modern, and ballet dance forms that could have relevance and suitability for dancesport training, and propose several strategies for inclusion in the current dancesport curriculum. **METHODS:** We reviewed articles derived from Google Scholar, PubMed, ScienceDirect, Taylor & Francis Online, and Web of Science search engines and databases, with publication dates from 1979 to 2013. The keywords included MeSH terms: *dancing, gymnastics, physiology, energy metabolism, physical endurance,* and *range of motion*. Out of 47 papers examined, 41 papers met the inclusion criteria (validity of scientific methods, topic relevance, transferability to dancesport, publication date). Quality and validity of the data were assessed by examining the methodologies in each study and comparing studies on similar populations as well as across time using the PRISMA 2009 checklist and flowchart. **RESULTS:** The relevant research suggests that macro-cycle periodization planning, aerobic and anaerobic conditioning, range of motion and muscular endurance training, and performance psychology methods have potential for adaptation for dancesport training. **CONCLUSIONS:** Dancesport coaches may help their students fulfill their ambitions as competitive athletes and dance artists by adapting the relevant performance enhancement strategies from gymnastics, figure skating, and concert dance forms presented in this paper. *Med Probl Perform Art* 2015; 30(4):238–250.

DanceSport training includes technical, artistic, choreographic, and competitive elements; however, there is no established training methodology that specifically targets aspects of conditioning and performance preparation within the practice. For example, in terms of physical and psychological preparation for competition, dancers generally do not sufficiently warm up before, or cool down after, their performances,[1] nor are they familiar with formal stress-coping strategies.[2] There are numerous ballroom technique resources on the market,[3] but the topics of performance psychology and career planning for competitive dancers only receive brief mention in just two book-length publications.[4,5] Another training limitation is that dancesport competitors do not learn how to train across seasons or over the duration of their careers. Unless they learn these skills in vocational settings, such as college or university programs, many dancers remain unmindful of strategic planning over time.[5] To address these important problems, here we present basic principles for improving training for the uninitiated.

Although participants may be unaware of best practices, recent studies suggest that dancesport is an activity with high physiological and psychological demands. The maximal oxygen intake (VO_{2max}) in competitive ballroom dancers during competition simulation has been shown to be comparable to that of swimmers or gymnasts[1] and higher than in other dance forms.[6] They tend to work at 80% or more of their VO_{2max}[7] and can expend up to 9.9±3.7 kcal on average per dance.[8] Mentally, ballroom dancers are exposed to many external and internal psychological stressors during competitive events,[2,9] potentially leading to chronic stress symptoms.[10] Due to these particular demands of this dance form, it would be beneficial to develop seasonal planning, conditioning, and perform- ance psychology education strategies to help dancers cope with the career-long strain of competitions and training.

Other forms of competitive aesthetic sports such as gymnastics and figure skating have benefited from sport science research on such topics as periodization of training, conditioning, and performance psychology. Consequently, coaches and teachers in these disciplines have developed many strategies and tools for training and teaching that have allowed their practitioners to push their abilities beyond previous expectations. In this study, we identify conditioning methodologies in gymnastics, figure skating, and contemporary, modern and ballet dance forms that could be relevant and suitable to dance- sport. As a starting point for practitioners who may not

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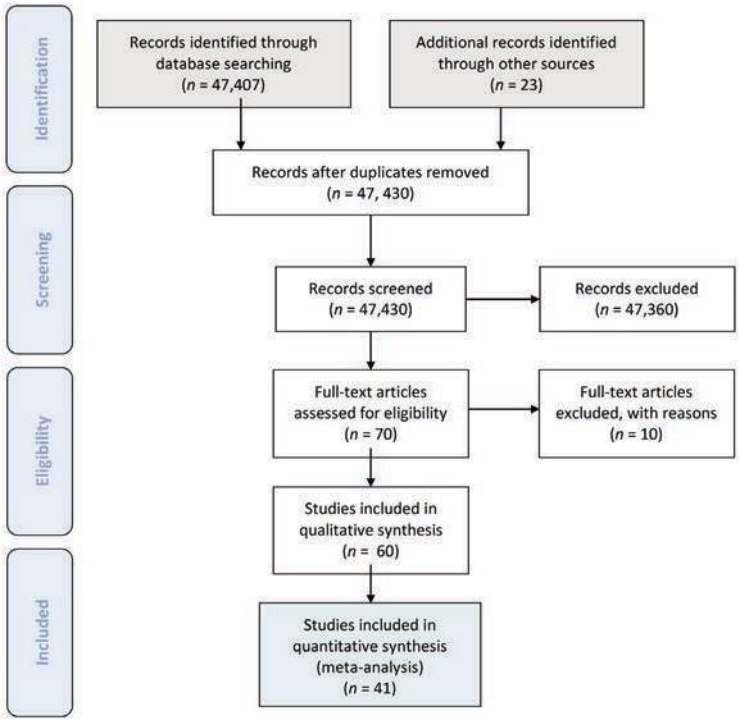

FIGURE 1. PRISMA 2009 flow diagram, showing selection of articles for the literature review.[14]

be familiar with training outside dance, we propose several strategies for their implementation in the current dancesport curriculum. In particular, we recommend the use of macro-cycle periodization as the basis of the competitors' yearly training schedules; supplemental aerobic, anaerobic, muscular endurance, and range of motion training to improve the dancers' physiological capacities; and psychological preparation methods for the competitive environment.

MATERIALS AND METHODS

We conducted a literature review between January 11 and April 11, 2013, using Google Scholar, PubMed, ScienceDirect, Taylor & Francis online, and Web of Science search engines and databases. The keywords included the following MeSH terms and PubMed subject headings: *physical education and training, physical conditioning, energy metabolism, aerobic exercise, physical endurance, resistance training, muscle strength, overuse injuries, distributed practice, periodization, muscle spindles, range of motion, muscle stretching exercises, gymnastics, figure skating, ballet, ballroom dancing, dancing, physiology, psychology, competitive behaviour*. (Additional sub-terms appear in Appendix 1 online). The inclusion criteria consisted of validity, publication date, relevance, and transferability. The initial search yielded 47,407 results from which we included only articles published in academic peer-reviewed journals between 1979 and 2013, although additional documents were used as supporting materials for conditioning strategies proposals. A detailed diagram of our search is presented in Figure 1.

Articles were included if they claimed to study improvements in the following aspects of physical activity: periodization, muscular strength or endurance, cardiorespiratory fitness, range of motion (ROM) training, psychological well-being, and aesthetic competence. Inclusion further required that the strategies proposed in the article addressed the needs of dancesport as presented by evidence-based research in this dance form[1,2,6–11] and could potentially be applied to training in conjunction with competitors' regular training and competition programs.[12,13] In particular, we focused on physiological and psychological performance necessities for dancesport competitors, within the confines of their extant training schedules. We excluded articles in languages other than English and con- ference proceedings in order to focus our search. We excluded as irrelevant studies dealing with subject matter in cell biology, history, elderly populations, concussion research, and anthropology. We also excluded more closely- related studies that dealt with biomechanics of gymnastics, acrobatic training, figure skating on-ice training injuries, altitude training, and studies looking at specific muscle actions in periodized training for cycling sports as non-transferable to dancesport.

LITERATURE SEARCH RESULTS

In total, 41 articles met the inclusion criteria and 18 additional sources were used as supporting materials (Figure 2). We examined research that dealt with periodization planning in physical activity (8 papers), reports that analyzed the physiological demands of and suggested training strate-

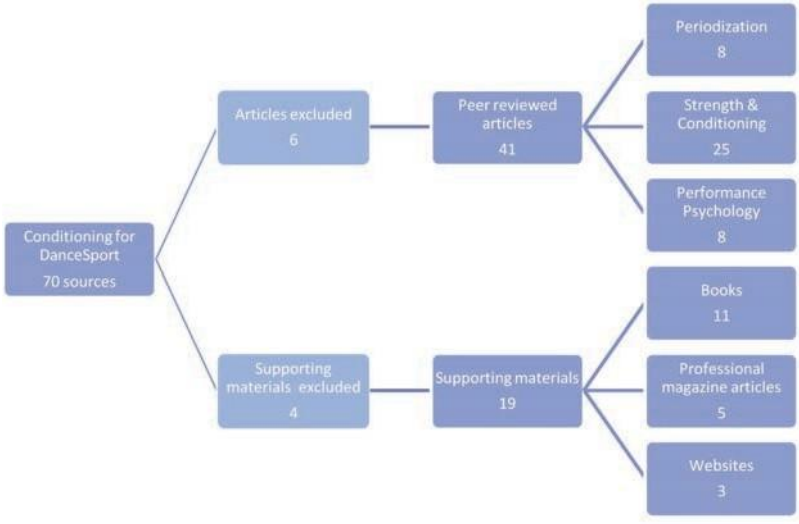

FIGURE 2. Materials and sources.

gies for sports and dance (25 papers), and articles dealing with performance psychology in various athletic pursuits (8 papers). Our supporting materials included book-length publications dealing with ballroom dance technique, periodization, exercise metabolism, psychological advice for dancers, and resistance training (11 books). We also utilized research-based articles examining practical periodization and fitness strategies (5 articles) presented by established scholars in conditioning periodicals. Finally, for competition schedules we used the official websites of the main dancesport associations, and for teaching materials available on the market, a popular website of ballroom dance goods and resources (3 websites).

The articles dealing with *periodization* (Tables 1 and 5) focused on comparing different tapering strategies, incorporating periodized training into gymnastics schedules, distributed practice in concert dance, and programming high intensity interval training. *Strength and conditioning* articles (Tables 2, 3, and 4) were divided into those outlining the fitness demands of dancesport; aerobic and anaerobic conditioning programs for gymnastics, figure skating, and concert dance; and resistance training for aesthetic sports, stretching protocols, and the relationship between aesthetic competence and fitness in physical activity with artistic components. *Performance psychology* articles (Table 6) dealt with the main stressors of dancesport competitors, the physiological responses of ballroom dancers to competition stress, anxiety and depression in ballet, and potential solutions to stress-induced conditions in performance sports by means of imagery, self-talk, and relaxation techniques.

The books included in supporting materials provided further insight into professional perspectives on psychological needs of dancers, technical requirements of ballroom dance, and fuller definitions and application of periodization, exercise metabolism, as well as resistance training in sports. The magazine articles provided professional advice on emerging stretching techniques, anaerobic conditioning, and periodization. The websites provided an up-to-date picture of the dancesport industry.

Abbreviations

Activities	
DSp	Dancesport
Con	Concert dance
Gym	Gymnastics
FS	Figure skating
Parameters	
Aero	Aerobic
Anaero	Anaerobic
ME	Muscular endurance
MS	Muscular strength
ROM	Range of motion
AC	Aesthetic competence
Met Cond	Metabolic conditioning
Measures	
VO_2	Oxygen consumption
HR	Heart rate
EE	Energy expenditure
MET	Metabolic equivalent
$[La^-]_b$ or BLa	Lactate concentration
kcal	Kilocalories

DISCUSSION

In following section, we identify conditioning methodologies from gymnastics, figure skating, and contemporary, modern, and ballet dance forms, identified in our literature search, that could have relevance and suitability for dancesport practitioners. The relevant research suggests that macro-cycle periodization planning, aerobic and anaerobic conditioning, ROM and muscular endurance training, and performance psychology methods have potential for adaptation for dancesport training. As a starting point for practitioners who may not be familiar with training outside dance, we propose several strategies for their implementation in the current dancesport curriculum.

TABLE 1. Broad Periodization Themes

Strategy	Preparatory Mid-Jun.–Mid-Aug. First half Jan.	Competitive Mid-Aug.–Mid-Dec. Mid-Jan.–Mid-May	Transition Mid-Dec.–Begin Jan. Mid-May–Mid-Jun.
Strength, conditioning	Cross-train, Met Cond, ME, ROM. High volume, high intensity	Cross-train, Met Cond, ME, ROM. Low volume, high intensity	Cross-train, Met Cond, ME, ROM. Low volume, low intensity
Dance-specific training	Choreography	Artistic expression Technique	Rest and recovery therapy Competition simulation
Performance psych.	Practice: Communication Breathing, imagery, self-talk, visualization Nine-step model	Training: Communication, imagery visualization Performance: Breathing Self-talk Nine-step model Self-talk	Breathing, visualization

Met Cond, metabolic conditioning; ME, muscular endurance; MS, muscular strength; ROM, range of motion.

Periodization

Rhea et al.[30] describe periodization as a method of manipulating acute workout variables to facilitate recovery and improve gains in fitness. This approach has been recommended by Wyon as suitable model for professional and vocational dance training in concert dance styles[31] and can be used to achieve specific or multiple conditioning goals. It provides a well-rounded structure for training that could serve as a model for the organization of conditioning and practice schedules in dancesport. Here, we combine periodization with Delorme's[32] principle of progressive overload to suggest potential training plans for competitive ballroom dancers (Table 1). The progressive overload principle states that in order to improve their fitness levels, dancers should at first be barely unable to complete the workout and then increase the workload volume and intensity as their bodies adapt to it.

When discussing periodization for collegiate gymnastics, Brooks[33] outlines the approach in terms of macro-meso-micro-cycles, which define the time length of the training program as well as its characteristics. *Macro*-cycles generally refer to annual or seasonal schedules, *meso*-cycles to periods of 2 to 6 weeks, and *micro*-cycles to weekly training plans.[34,35] The macro-cycle or the annual conditioning program can also be subdivided into *preparatory*, *competitive*, and *transition* phases in order to make the planning more manageable.[33–36] Although the seasonal competition cycles in competitive ballroom dancing vary by jurisdiction, dancers generally participate in competitions 8 to 10 months of the year, often having some time off during the winter and summer holidays.[5,12,13] While this is a longer competitive cycle than other sports and makes periodization planning more difficult, a modified schedule conforming to the reality faced by dancesport competitors could be beneficial for these athletes.

Bompa and Carrera[36] propose several such adjustments for various sports, including two and three peak cycle sports, suggesting that proper planning should work around the athlete's schedules. In dancesport, competitions are organized throughout the year in ascending importance. Regional and national qualifying championships occur between January and April and world championships take place between August and December. We propose using this general arrangement as a template for the development of a macro-cycle periodization schedule in this dance form (Table 1), adjustable to the needs of each competitive couple.[12,13]

Preparatory Phase

The macro-cycle preparatory phase is tailored to equip athletes for the upcoming competition season and helps them develop physiological, psychological, and technical skills necessary for the competitive season in their sport.[35] In gymnastics, this phase usually involves the development of difficult technical skills or combinations, but also includes alternative forms of training such as cycling or swimming in order to improve overall fitness level.[33] In dancesport, this phase could include the development of fundamental actions, building of new choreography, and fitness training. Dancers could work on their balance, footwork, and postural alignment, as well as take time to integrate difficult figures and tricks into their choreographies. They could increase their aerobic and anaerobic capacities through such activities as cycling or running within the physiological ranges required for competition, work on muscular endurance using resistance exercises to be better prepared for the multiple submaximal muscle contractions during dynamic movements and the static holds necessary for ballroom dance, and develop the range of motion necessary for some of the choreographic figures in this dance form.

TABLE 2. Physiological Characteristics of DanceSport Competitors

Study	Activity	Demographics/ Anthropometrics	HR Rest	HR Max (lab)	HR Max (field)	VO_2 Rest	VO_2 Max (lab)	VO_2 Mean (field)	$[La^-]_b$ Rest	$[La^-]_b$ Field	$[La^-]_b$ Lab	Peak Power *W/kg*	Energy Expenditure *kcal*	Intensity *MET*	Notes
Bria et al., 2011[1]	DSp														Anaero, Aero
Male (6)	Latin	Yes/Yes	—	194.8	183.5	—	59.2	47.8	1.30	6.04	*	16.5	—	—	
	Standard			192.9	175.7		60.9	45.8	1.55	6.50		17.4			
Female (6)	Latin	Yes/Yes	—	191.0	182.4	—	52.3	39.7	1.30	7.95		14.6	—	—	
	Standard			197.6	179.2		53.7	38	1.39	6.91		12.8			
Blanksby & Reidy, 1988[7]	DSp			‡			‡	‡	†					†	Aero, EE
Male (10)	Latin	Yes/Yes	55	197.6	168	0.2	52.5	42.8	—	—	—	—	54.0	—	
	Standard		55	197.7	170	0.2	52.5	42.8					54.1		
Female (10)	Latin	Yes/Yes	63	194.5	177	0.3	42	36.1	—	—	—	—	43.2	—	VO_{2max} pred.
	Standard		63	196.6	173	0.3	42	34.7					41.6		
Liiv et al., 2012[6]	DSp														Anaero, Aero
Male (7)	Latin	Yes/Yes	—	195.9	181.8		61.3	—	1.8	12.4	11.7	—	—	—	
Male (12)	Standard			191.8	170.6		59.6		1.6	8.7	11.6				
Females (7)	Latin	Yes/Yes	—	191.6	191.1		53.6	—	2.1	8.3	7.5	—	—	—	
Females (12)	Standard			193.3	173.8		51.8		1.8	7.5	8.4				
Massida et al., 2011[8]	DSp														EE, MET
Male (5)	Latin	Yes/Yes	—	—	—	—	—	—	—	—	—	—	52.8	6.1	
Female (5)	Latin	Yes/Yes	—	—	—	—	—	—	—	—	—	—	39.1	5.8	

Number of participants are given in parentheses.

* Not in text. †Predicted gross values calculated from individual regression equations using overall individual mean HR. ‡Average of male and female together.

Aero, aerobic; Anaero, anaerobic; EE, energy expenditure; ME, muscular endurance; MET, metabolic equivalent.

Competition Phase

According to periodization models, during the competition phase athletes' training should generally decrease in volume (the number of repetitions or exercises) and increase in intensity (the amount of effort or power output used per task) as well as technique training, to avoid overtraining and fatigue during competitions.[34–36] In gymnastics, the competition phase is usually a very busy period, and nonspecific training shifts to very low-volume, including only maintenance-based protocols for both technique and physical conditioning. The intensity of gymnastics-specific training, however, remains at peak levels and even increases.[33]

Similarly, in dancesport, during this time, the technical practice sessions can diminish and the dancers could concentrate on competition simulation training instead. Choreographies should remain the same during the competition phase, and the dancers should focus on improving their stamina and artistic expression while practicing their routines. If time permits, dancesport competitors could continue their supplementary fitness training at lower volumes or simply monitor their dance practices in terms of exercise metabolism in order to maintain the levels obtained during the preparatory season. Finally, they should follow the appropriate stretching and warm-up protocols during training and competition.[19,37,38]

Transition Phase

The transition phase, a recovery period between the competition and preparatory phases in the periodization macrocycle, consists of nonspecialized activities where both intensity and volume are reduced and restoration is the main objective.[30,34–36] During this phase, Brooks[33] recommends that gymnasts rest and participate in low-volume, low-intensity cross training activities such as cycling or swimming. Bompa[36] adds that this phase should also address nutrition, sleep, and regenerative therapeutic techniques. In this way, athletes can maintain a baseline fitness level while recovering from any injuries incurred during the competitive phase. Ballroom dancers can also take time to rest and seek appropriate medical experts for any injuries they may have sustained[39,40] while continuing a baseline fitness training protocol.

Conditioning Strategies for DanceSport

Currently, in the majority of dancesport studios, dance itself is considered the primary or even exclusive form of fitness training for the dance athletes. This approach, while accepted by most dancers, is based mainly on anecdotal evidence and personal experience of the teachers. Koutedakis and Jamurtas[26] point out that this methodology is often rooted in the false belief among dancers that fitness training will negatively affect aesthetic appearances. The authors also state that dancing alone is insufficient as a conditioning strategy for dancers.[26]

In dancesport, the maximal oxygen intake (VO_{2max}) has been shown to be comparable to that of swimmers or gymnasts[1] and higher than in other dance forms.[6] During competition simulation experiments, competitive ballroom dancers showed VO_2 and heart rate (HR) values close to or above their own maximum values taken on a treadmill test in the lab,[1,6,7] and in the Latin and ten dance categories, dancers have often surpassed their own anaerobic thresholds established by lactate concentrations during the lab treadmill test.[6] Considering these results, supplementary fitness training could be beneficial for competitive ballroom dancers, as it could improve their aerobic and anaerobic capacities.[1,6,41] Ameliorations in these areas could bring about a decrease in fatigue and improve recovery time between high intensity dance bouts,[42,43] resulting in improved neuromuscular control and mental concentration necessary for an aesthetically competent performance.[17,23,44] Table 2 presents further data on the physiological demands of dancesport.

Muscular endurance is another fitness element that has been shown to be beneficial for performance in dance,[17,23] as well as in gymnastics[18,33] and figure skating.[22,21] Although it was not tested on ballroom dancers in the studies discussed here, muscular endurance training has potential to be a useful tool for conditioning in dancesport. Taking the strategies from contemporary dance, gymnastics, and figure skating as models (Tables 3 and 4), we suggest a basic muscular endurance program for ballroom dancers focused on the muscle groups and movements often used in this dance form.[45–48] Similarly, ROM training has not been studied for ballroom dancers in the articles surveyed but has been suggested as an important element in concert dance training[24,38,44] and has been shown to improve aesthetic and physical performance as part of a conditioning plan in ballet, gymnastics, and figure skating.[19,20,22] Combining these studies with general research on stretching proto- cols[49–52] (Tables 3 and 4), we suggest a basic ROM training protocol for ballroom dancing based on the needs of this style. We place each fitness protocol in a periodization plan designed for dancesport (Table 5).

Aerobic and Anaerobic Conditioning

Aerobic training is usually of long duration (20–40 min), around 70 to 80% of maximum heart rate (HRmax), and utilizes oxygen, while anaerobic training is usually of short duration (<20 min), around 80 to 90% HRmax, utilizing reserves of the metabolic fuel adenosine triphosphate (ATP) with blood lactate as a byproduct. At rest, blood lac- tate is around 1 mM, whereas at the exercise intensity where anaerobic metabolism begins, the rate increases to 2 mM. The two systems do not work in isolation; however, the aerobic system simply takes longer to start up but can begin to play an important role in energy production even after 2 min of exercise, depending on the athlete's initial condition, and the anaerobic system can still be activated past 20 min of exercise if the intensity rises above maxi-

TABLE 3. Results of Conditioning Program Studies in Concert Dance, Gymnastics, and Figure Skating

			HR			VO_2			$[La^-]_b$			
Study	Activity	Demographics/ Anthropometrics	Rest	Max (lab)	Max (field)	Rest	Max (lab)	Mean (field)	Rest	Field	Lab	Condition Type
Angioi et al., 2012[17]	Con	Yes/Yes										Aero, ME, MS, AC
Pre					196*							
Post					177*							
Durall et al., 2009[18]	Gym	Yes/Yes										ME
Guidetti 2009[19]	Gym	Yes/No										Warm-up, ROM, AC
Guidetti 2007[20]	Con	Yes/Yes										Warm-up, ROM
Mannix et al., 1996[21]	FS	Yes/Yes										Aero, ME
Pre								50.7				
Post								55.9				
Mcmaster et al., 1979[22]	FS	Yes/Yes										Aero, ME, ROM
Pre								44.7				
Post								52.5				
Mistiaen et al., 2012[23]	Con	Yes/Yes										Aero, ME
Pre								27.6				
Post								29.7				
Smol & Fredyk, 2012[24]	Con	Yes/Yes										Anaero, Aero, AC
Pre				80	177		0.4	38		1.8		7.8
Post				79	179		0.3	40		1.7		7.9

*DAFT HR test. Con, concert dancing; Gym, gymnastics; FS, figure skating. AC, aesthetic competence; Aero, aerobic; Anaero, anaerobic; ME, muscular endurance; MS, muscular strength; ROM, range of motion.

mum VO_2 levels and oxidative phosphorylation is unable to produce sufficient ATP turnover.[37]

During a typical competition, ballroom and Latin competitors usually dance several intermittent rounds with breaks of 30 min to a few hours in between. Each round includes four to five dances, with each dance lasting 1 min 40 sec and with 15–30 sec breaks in between.[12,13] Bria et al.[1] describe dancesport as a discipline characterized by medium-lasting and high-energy demanding consecutive phases, separated by short recovery periods, and suggest that dancers would benefit from strong foundations in both aerobic *and* anaerobic fitness. The results of their study show that during simulated competition, dancers had VO_2 and HR values of up to >80% of their VO_{2max} and HRmax recorded in the lab. For example, Latin-category male dancers had a VO_{2max} of 59.2±7 mL/kg/min recorded on a treadmill in the laboratory, and showed relative VO_2 values of 47.8±7.2 mL/kg/min during the competition simulation. At the same time, their blood lactate (BLa) levels were on average >4 mmol/L after the first dance, and their relative HR was 95.5±1.5%, demonstrating that dancesport is likewise an activity with high anaerobic demands. Liiv et al.[6] comment that improving aerobic endurance would help competitive ballroom dancers withstand multiple competition rounds without exhaustion, while conditioning their anaerobic metabolism would assist them in the short bursts of energy necessary for each dance and allow them to increase their anaerobic threshold. These ameliorations could in turn improve dancers' balance and coordination by delaying the onset of muscle fatigue.

Several methods exist for the general improvement of aerobic and anaerobic capacities in athletes, but in order to maintain a degree of specificity to dancesport, here we present only validated strategies used in other aesthetic sports with similar physiological demands. For example, figure skating is a sport where the artistic expression also forms part of the judging criteria. Equally, high VO_{2max}, as well as the ability to produce and tolerate high blood lactate levels, enables skaters to perform at maximum physiological capacities during long and short skating programs.[21,53] In consideration of these requirements, the traditional "fitness training through skating alone" was deemed insufficient for elite skaters. Moderate- to high-intensity fitness training on and off ice, such as interval training for aerobic capacity and ergometer cycle for the anaerobic capacity, was recommended to supplement the regular routine.[22,53] Augmentation of dance training with fitness programs to improve performance capacity has also been suggested for modern and classical ballet dance forms.[20,24,44] These strategies could potentially benefit dancesport athletes and help them meet the high aerobic and anaerobic demands of competitive ballroom dance.

As a template for teachers, trainers, and dancers who may not be familiar with training outside dance, the following information could provide a starting point for a research-based training program planning (Table 5). Dancers could work on cardiovascular endurance by running, cycling, or rowing for half an hour three times a week while maintaining between 60 to 85% of their of their age-

TABLE 4. Main Themes of Review Articles

	Activity	Periodization	Met Cond	ME, MS, ROM	Other
Batson, 2007[25]	Con	Transition phase			Rest, recovery
Brooks, 2003[33]	Gym	Multifactorial approach model	Cross-training Gymnastics training	Submaximal resistance and circuit training Stretching	Social, nutritional, and academic considerations
Delorme & Watkins, 1948[32]	DSp		Progressive overload	Progressive overload	
Koutedakis & Jamurtas, 2004[26]	Con		Supplementary fitness training	Injury prevention Aesthetic competence	Body composition and mass Overtraining
Krasnow et al., 1997[27]	Con			Conditioning with imagery	
Nastase, 2012[11]	DSp				Artistic communication
Nastase, 2012[28]	DSp				Performance capacity model
Rafferty, 2010[44]	Con		Supplementary dance fitness training	MS: Dance-specific plyometric training	Specificity principle Somatics Motor learning Psychology
Sanchez et al., 2013[29]	Gym	Optimized tapering and overload approach			Individualization principle
Wyon, 2010[31]	Con	Preperformance tapering			

Met Cond, metabolic conditioning; ME, muscular endurance; MS, muscular strength; ROM, range of motion.

predicted HRmax: (220–age)*0.6 to (220–age)*0.85.[22,37] Following Delorme's[32] principle of progressive overload, athletes only develop new capacity when they push slightly beyond their current capacity. So a program to improve fitness level needs to begin with a workout with sufficient intensity that the dancer barely cannot complete it. As the dancer masters each higher intensity, the workout should then become progressively more intense.

This workout strategy could also be adapted to have an anaerobic element specific to dancesport in terms of time limits and intensity (Table 5). Dancers could divide these running, cycling, or rowing workouts into 5 to 10 interval phases,[41] each consisting of 120 sec of high-intensity activity and 10 sec of light-intensity activity. These time divisions are slightly longer than high-intensity periods and shorter than light-intensity periods during dancesport competition rounds, following the principle of progressive overload. If necessary, longer low-intensity periods, of up to 30 sec, could be used at the beginning to allow the body to adapt to the exercise. In terms of heart rates, this would mean maintaining 80 to 90% of their maximum age-predicted heart rate: (220–age)*0.8 to (220–age)*0.9 for the high phases and allowing it to go as low as half that rate or lower for the light phases.

If heart rate measurements are not available, the rating of perceived exertion (RPE), a self-assessment scale (ranging from 6–20) to rate breathlessness and fatigue during exercise, could be used. The aim should be 18–20 RPE for the high-intensity phases and 10–12 RPE for the light phases. This type of exercise should not make up more than 10% of the weekly training volume due to its intensity.[41–43] However, since a typical competition round consists of four or five dances lasting a minute and a half each, 10 to 20 min of such a workout per week should improve the dancers' lactate threshold enough to sustain a full competition round, which is usually followed by a longer rest period allowing the competitors to recover before the next performance.

This conditioning program can be adjusted based on each dancer's individual constitution. For example, if they have trouble maintaining intensity for the whole bout of dances, they can focus on aerobic training. Alternatively, if they have trouble recovering between bouts, they can prioritize anaerobic conditioning. However, based on the balance of evidence, most dancers would benefit from improving all aspects of cardiovascular fitness.

This portion of the training will have its main focus in the preparatory section of the periodization schedule and should allow the dancers to build aerobic and anaerobic capacities for the competitive season. During the competitive season, this program can be continued in a maintenance mode with lower volume and can be substituted by regulated dance-specific practices where the dancers would monitor the intensity and volume of their dance training in the same manner they would with cross-training.

TABLE 5. Periodization Strategies for DanceSport

	Preparatory	Competitive	Transition
Metabolic conditioning			
Aerobic	Cross-train 30 min 3 times a wk 60–85% HRmax	Dance-specific exercises or cross-training: 1–2 a wk Maintenance: 60–85% HRmax	Cross-train Own pace
Anaerobic	Cross-train 15 min 2 times/wk Intervals: 2 min 80–90%HRmax 30 sec 40–50% HRmax	Choreo. run-through or cross-train: 1 time/wk Maintenance intervals: 2 min 80–90% HRmax 10–30 sec 40–50%	Cross-train Intervals Own pace
Muscular endurance			
Static:			
Upper body	Straight arm lifts to 90º front and side. (1.5–2.5 kg)	Same as prep. cycle	Same as comp. cycle
Lower body	Double and single lying leg lifts. Standing *releve*, on one or two legs	Add 1.5–2.5-kg weights and use dance movement	Same as comp. cycle but can decrease weight
Dynamic:			
Upper	Biceps/triceps curls Humerus out/in rotations (1.5–2.5 kg)	Same as prep. cycle but use dance arm movement	Same as comp. cycle but can decrease weight
	Scapular push ups Shoulder depressions	Same as prep. cycle	Same as prep. cycle
Lower	Lunges forward, side, back Squats	Add 1.5–2.5-kg weights and use dance movement	Same as comp. cycle but can decrease weight
Frequency	3 times a wk	1–2 a wk	1–2 a wk
Static	5–10 reps, 5–10 sec hold	Same reps, 10–15 sec or more, hold dance frame	Decrease weight/reps/hold
Dynamic	15–30 reps	12–25 reps	10–30 reps
Range of motion			
Type	Static or PNF	Static or PNF, micro	Micro 3–
Frequency	5 times a wk	5–7 a wk	5 a wk
Timing	Post warm-up or practice	Static or PNF: post warm-up or practice Micro: post-performance	Post warm-up or practice
Objective	Increase ROM	Maintain ROM	Recovery, rest

PNF, proprioceptive neuromuscular facilitation; ROM, range of motion.

Finally, during the transition phase, this training can be continued at lower intensity and volume with focus on regeneration and recovery (Tables 1 and 5).

Muscular Endurance Training

Two studies in our review have shown that muscular endurance training, as a part of a supplemental fitness program for dancers, can improve dancing quality and fitness levels in contemporary dancers (Table 3). Angioi et al.[44] observed improvements in upper body muscular endurance and aesthetic competence after a 6-week program of circuit and vibration training performed for 1 hour, twice a week. Mistiaen et al.[23] also used circuit train- ing with free weights and resistance equipment to supplement the dance training in a vocational program and observed improvements in aerobic muscle endurance. Similarly, studies in figure skating[21,22] and gymnastics[18,33] have shown improvements in fitness and performance of athletes by using programs that included muscular endurance training as part of a conditioning program.

Here, we present a basic resistance training program adapted to dancesport from the research above. Using a graduated method incorporating static and dynamic light weight training, we suggest an exercise plan that can be incorporated into the periodized macro plan we outlined earlier. This training can be done at high intensity and volume in the preparatory season, reduced volume in the competitive season, and lower both volume and intensity in the transition period (Table 5).

Lightweight barbells (1.5–2.5 kg), which should allow lean muscle development aesthetically required in this dance form, could be used to perform isometric and dynamic exercises for the upper and lower body. Static shoulder flexion and adduction at 90° can be done to improve the dancers' static isometric contraction endur-

ance, and biceps/triceps curls as well as inward/outward rotations of the arm can be done to strengthen the forearm and rotator cuff muscles. Shoulder depressions and scapular push-ups can also be done to stabilize the scapula.[54] This type of resistance training would help dancers develop upper body muscular endurance, fundamental for a strong ballroom frame in the standard category, a position in which the elbows are usually held at or just below shoulder level,[45] and facilitate the arm flexion and abduction in the Latin category during movements such as the New York and hand-to-hand in the rumba and cha cha cha.[46,48]

Dancesport also requires a strong core to maintain an erect posture during complex dance movements and necessitates lower limb endurance during many squatting and lunging figures, such as the whisk in samba[47] or back corte in tango.[45] Lower limb exercises such as basic squats and lunges to the front, side, and back can improve muscular endurance in the hip and knee flexors/extensors needed for these actions. Furthermore, abdominal core strengthening exercises such as lying double leg lifts and holds could be incorporated into the program[54] to strengthen the deep and superficial abdominal muscle groups needed for core control. By increasing the holding time, the angle of the hold, or the number of repetitions, dancers can increase the difficulty level of this training if necessary.

Dancers can use these exercises selectively depending on their individual needs. For example, upper body training will be particularly useful for dancers who find it difficult to hold their frame or cannot support their partner's weight, while lower body training will benefit dancers who have trouble with the repetitive lunge and squat actions used in dancesport. As with metabolic endurance training, the overload principle dictates that muscular endurance training needs to challenge the athletes' present capacities in order to improve them.[32] Tables 1 and 5 provide an example of a periodized muscular endurance program for ballroom dancers.

ROM Training

Several authors of articles covered in this review point out that stretching is a necessary element of fitness for dancers due to the demands on flexibility in today's choreographies.[24,38,44] Furthermore, in gymnastics and figure skating, ROM training as part of a performance preparation routine and supplementary fitness program has been used successfully as a performance enhancement tool.[19,22] Although this review did not reveal any literature dealing with ROM training specifically for ballroom dance, based on the balance of evidence from other disciplines (Tables 3 and 4), it can be assumed to be a reasonable conditioning technique for this dance form as well. In particular, female dancers who are having trouble performing complex movements and postures requiring flexibility could benefit from developing their ROM. We propose programs from the above-mentioned studies as models for a dancesport ROM training protocol (Tables 1 and 5).

Stretching techniques that aim to improve the ROM should be performed after an active warm-up or after athletic activity. There is some evidence from the proprioception literature that the sense of limb location is influenced by semi-stable protein cross-bridges in muscle fibers.[49] By extension, stretching to a novel ROM immediately before exercise might lead to a distorted perception of limb location[55,56] and increase the risk of potential injury.

Competitive ballroom dancers should focus on improving ROM in the muscle groups widely used in dancesport, such as cervical spine extensors and rotators, shoulder girdle retractors and depressors, knee extensors, external and internal hip rotators, trunk extensors, hip flexors, and plantar flexors. Flexibility in these structures is important for walking, lunging, and rotary hip actions common in dancesport as well as for back extensions and posture maintenance in the ballroom category. Stretching these areas may help dancers avoid potential overuse of the muscles involved in these actions.[39,40] In this section, we discuss three types of stretching techniques: static stretching, proprioceptive neuromuscular facilitation (PNF) stretching, and microstretching.

Static stretching is a commonly accepted stretching technique for increases in ROM. It is characterized by holding a position where a stretch is felt at around 8 out of 10 intensity level, just before the onset of the autogenic inhibition reflex (the point at which the muscle starts to shake), for a 15–60 sec duration.[38] In order to be effective, static stretching exercises should be performed at least 5 days a week.[52] To progressively benefit their flexibility, dancers need to slowly increase their ROM over a number of sessions.

Another stretching protocol potentially useful for dancesport is *PNF stretching*. In this technique, the target muscle is isometrically contracted for 10-15 sec before stretching to inhibit contraction during the subsequent stretch, therefore allowing for greater ROM. To further develop this technique, the opposite muscle can be contracted during the stretch phase, thereby facilitating increased ROM in the stretched muscle.[38] PNF stretching can be used in conjunction with or instead of static stretching, after exercise five to seven times a week, and following the same slow progressive increases in intensity over several sessions. The intensity of PNF stretching can range from 2 to 8 out of 10 depending on the dancer's capacities, since using submaximal intensity in this stretching technique does not significantly affect results.[50,51]

Recent research also recommends a strategy called *microstretching*. As a low-intensity stretching technique used 2 hours after exercise, microstretching can be effective in allowing the lengthening and adaptation in the myofilaments and muscle fibers. This type of stretching should be held up 60 sec on each targeted muscle group at a low intensity of about 3 to 4 out of 10 and has been shown effective in increasing ROM in dancers.[38,57] Microstretching can be used after performances or when the dancer is fatigued because of its low intensity and limited potential for muscle

TABLE 6. Main Themes of DanceSport Psychology Articles

Study	Activity	Physiological Responses	Psychological Stressors	Potential Solutions
Berndt et al., 2012[10]	DSp	Increased IL-6, attenuations in the HPA axis and SNS	Self-reported health complaints and stress evaluation	Further research
Čačković et al., 2012[2]	DSp	n/a	Internal and external stress factors during competition	Recognizing personality types Competition preparation
Čačković et al., 2012[15]	DSp	n/a	Lack of preparation for competition	9-Step competition preparation model
Rohleder et al. 2007[9] (experiment)	DSp	Higher cortisol levels during competition day	Social evaluative threat	Further research
Tremayne & Ballinger, 2008[16]	DSp	n/a	Interpersonal conflicts Performance anxiety	Preparation Communication Anxiety coping Imagery

IL-6, interleukin-6 (inflammatory cytokine); HPA, hypothalamus-pituitary-adrenal; SNS, sympathetic nervous system.

fiber damage. As previously stated, the best time to improve ROM through stretching may be after the exercise, when muscles are thoroughly warm and there is no immediate risk of injury because of a skewed sense of proprioception. Table 5 provides an example of a periodized program for ROM training in dancesport.

Psychological Considerations

While physical conditioning methodologies address the fitness levels necessary for dancesport competitors, considering the many stress factors in competitive ballroom dancing (Table 6), the psychological aspects of this practice also need to be taken into account as part of a comprehensive conditioning methodology.[2,9,10,15,16,58] Rohleder et al.[9] showed elevated cortisol levels among ballroom dancers as a response to social evaluative threat during a competition, and Berndt et al.[10] have found this population to be at risk of suffering from chronic stress syndromes. In dancesport, the participants are constantly scrutinized by their coaches, judges, and peers, a situation in which the dancers are prone to be affected and validated by external loci of control.[2] When discussing similar issues faced by female collegiate gymnasts, Brooks[33] states that dependence on outside validation of self-worth correlates with low self-esteem, and therefore education in the management of self-image and stress would be highly beneficial in this environment. Better psychological preparation could save many dancers from potential mental and physical problems caused by these factors.[2,59,60]

Moreover, since ballroom involves long-term partnering between dancers, a good working relationship between partners is very important for a positive and productive environment. Young dancers are often forced to deal with the issues of personality differences, divergent goals, and contrasting learning strategies with little preparation or advice, which can lead to unnecessary interpersonal conflict and an unproductive work atmosphere.[4,5] Unfortunately, dancesport coaches rarely address these issues with their students beyond brief anecdotal advice. Equally, little literature exists that covers these topics for ballroom competitors.

Tremayne and Ballinger[16] propose several stress coping strategies based on their research with ballroom dancers. They discuss communication strategies for couples, whereby the partners can discuss the various scenarios that create communication breakdowns during practice and try to develop compromises for dealing with each other. They also suggest centering breath techniques to help dancers lower anxiety levels before dancing in competitions and the use of imagery to help build self-confidence and improve performance. They point out that dancers can work on dealing with external distractions in the studio in order to better anticipate them during performances. Additionally, they advise dancers to create a competition preparation checklist in order to lessen the stress in days before the event. Finally, the authors recommend positive self-talk and visualization of flawless performance to maintain focus on the day of the competition.

During the performance itself, Čačković, Barić, and Vlašić[15] propose using Winkelhuis'[5] nine-step preparation model (Table 7) in order to reduce competition stress and improve performance. They argue that with practice, this preparation can help dancers reduce stress and improve their performance during competitive events. Čačković et al.[15] recommend beginning to train with these methods early in the season in order make them habitual and effective. Dancers can begin to train them during the preparatory season, along with working on their interpersonal communication skills, use of imagery, breathing techniques, focus in the face of distractions, and positive self-talk. Dancers could use these techniques selectively depending on the needs of each couple. For example, if they are having trouble with competition anxiety, they can practice positive self-talk and centered breathing, and if they are not able to work together efficiently, they can

TABLE 7. Winkelhuis's 9-Step Preparation Model

Step No.	Name	Stage
1,2	Finish, applause	Ending of last dance
3,4,5	Relaxation, concentration, energy	Physical and mental preparation
6,7,8	Relationship, positioning, invitation	Entry into the next dance
9	Action	Next dance

Adapted from Winkelhuis, 2001.[5]

work on communication skills by going over possible conflict scenarios and finding compromises.

Occasional lectures by professional sports psycholo- gist could help dancers learn new coping strategies and evaluation questionnaires or interviews could provide the teachers with a better understanding of their stu- dents' mental states. If lectures are not possible, sports psychology literature could be made available in the studios to encourage further investigation of these topics by the dancers. If dancers prepare themselves during the preseason, they should be proficient enough in these techniques to use them effectively during the competition season. Some of these techniques such as the visualiza- tion of performance, centered breathing, and positive self-talk can be excellent ways to maintain psychological health without physical or mental exertion during the transition phase.

CONCLUSIONS

Dancesport is a physiologically demanding physical activity[1,6,8] with a significant psychological component.[2,9,10] However, scientific literature dealing with this discipline is scarce. The examination of the literature here was limited to the time frame available for the research, and more studies might be available since our original investigation. The breadth of the subject matter and the limitations on the space were also factors that influenced the organiza- tion and scope of this article. The first author's role as a professional ballroom dancer made him an insider researcher, but we attempted to reduce bias through the editing of the second author.

Until the literature is developed, we recommend that training strategies from gymnastics, figure skating, and concert dance be adapted for dancesport. Strategies such as periodization macro-cycles for yearly training planning, cross-training to promote the aerobic and anaerobic fitness, and muscular endurance and ROM exercises can benefit the fitness and aesthetic performance of these athletes. Additionally, stress and anxiety management strategies can enhance performance and improve mental well-being of the dancers. This review illustrates the substantial gap in the literature with respect to competitive ballroom dance, and future investigations should address the unique needs of these dancers. However, until that research is available this paper proposes a tentative conditioning strategy for dancesport, which will prove a valuable starting point for both researchers and dance educators.

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Supplemental material appears in the online version of this paper, available at www.sciandmed.com/mppa (see Dec 2015 issue, vol 30, no 4).

APPENDIX: Full Keyword List of MeSH Terms Used in the Literature Search

Aerobic training/dance
Ballroom dancing
Competitive behavior/physiology
Conditioning/dance/practice
Dance sport/psychology
Dancing/physiology
Dancing/psychology
Eating disorders/ballet
Energy metabolism/ballet
Figure skating training
Gymnastics physiology
Gymnastics training
Muscle spindles/physiology
Muscle/physiology/thixotropy muscle
Muscular strength/dance/importance
Overuse injuries/distributed practice/ dance
Periodization
Periodization/dance
Physical education and training methods
Physical endurance/physiology/periodization
PNF stretching
Progressive resistance exercise
Psychological preparation/ballroom dance
Range of motion/articular/static stretching
Static stretching warm up