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SPORT PERFORMANCE IN DANCE – A SYSTEMATIC REVIEW OF THE METHODS USED IN PHYSICAL CONDITIONING TRAINING

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ABSTRACT. To assist academics and coaches to better understand dance and the training methods, a literature review of all pertinent articles was conducted. Although it has been proposed that dancers should add strength training into their regimen, many dance institutions are either hesitant to do so or lack the resources or knowledge necessary to do it. It has been suggested that dancers are hesitant to engage in strength training because they are concerned about muscular hypertrophy and the potential effects it may have on dance aesthetics. However, recent study has indicated that this might no longer be the case and that attitudes toward strength training are changing, especially among dance students and professionals. We conducted a search into multiple database (PubMed, Google Scholar, ScienceDirect) to gather the most important research articles to achieve our purpose. Our key word for this search was: strength training, plyometric training, dancers, ballroom, resistance training. The inclusion criteria were as follows: healthy subjects (male or female) who participated in a type of supplementary training, articles no older than year of 2000. Exclusion criteria: ballet dancers, injury related articles, elderly participants.

Keywords: *ballroom dancing, training methods, strength, dance sport*

Introduction

Given the physical requirements and artistic talent needed for performance, dancers are sometimes referred to as athletes that compete on aesthetic (Ambegaonkar, Caswell, Winchester, Caswell, & Andre, 2012).

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Historically, dance has placed more of an emphasis on aesthetic aspects, with particular attention paid to execution, movement quality, and vocabulary, especially in modern dance and classical ballet (Yiannis Koutedakis et al., 2007), than on the necessity to develop the physiological systems to satisfy choreographic demands. Additionally, it has been argued that strength is not necessary for a successful dance career and that dancers frequently view fitness as the lack of injury rather than as an essential component of dance training (Koutedakis, Stavropoulos-Kalinoglou, & Metsios, 2005).

Sports dance consists of a series of steps and figures executed with a high degree of technicality and an artistic technicality and an artistic element of considerable complexity and coordination between the two partners, put together on a musical accompaniment unique to each dance. Sports dance reveals by the perfection of its steps a world of symbols, a gesture loaded with significance, which obeys the most subtle laws of biomechanics. Steps and dance movements are arranged in choreographies based on musical cues, spatial and temporal coordinates, and the presence of several partners on the dance floor (Adam, Simion, & Iconomescu, 2018).

While the majority of dance practice involves strenuous physical activity and has been shown to improve physical indicators, it is unclear if dancers would benefit from additional training (L. Bernardo & E. Nagle, 2006; Brown, Wells, Schade, Smith, & Fehling, 2007; Roussel et al., 2014).

Numerous dancers participate in several types of supplemental training, such as Pilates strength and plyometric exercises. Despite supplemental training's increasing popularity among dancers, there are a dearth of impartial studies evaluating the effectiveness of these on dance performance (Farmer & Brouner, 2021; Koutedakis et al., 2005).

Strength training has historically been thought to be unpopular among dancers owing to the misconception that it will drastically increase muscle size and detract from the dancer's body's attractiveness. However, with the rise in choreographic requirements, these attitudes regarding further training and the requirement to enhance some areas of physical fitness to satisfy these requirements start changing (Twitchett, Koutedakis, & Wyon, 2009).

Another form of training that dancers use is core stabilization training and vibration training. Numerous studies have shown that core stabilization training and vibration at a specific frequency improve the height of the high jump and increase the range of motion (Marshall & Wyon, 2012; Wyon, Guinan, & Hawkey, 2010).

Studies in dance styles other than ballet are few, according to academics in dance health and science (Bria et al., 2011; Kostic, Zagorc, & Uzunovic, 2004). To help coaches and trainers in better understanding competitive dance sport

and recreational ballroom and Latin dancers, the main goal of this study was to locate all pertinent dance sport literature. The subject of how supplemental training affect dancers' objective physiological parameters and their ability to perform in a functional manner is still open despite mounting evidence to the contrary. This systematic review's objective is to examine how different training methods used by dancers affects their performance.

Methods

Search strategy

Two researchers conducted a search of articles on the topic. The following databases were used to collect the required articles: PubMed, Google Scholar, ScienceDirect. The keywords used to identify the required articles were ballroom dancing, training methods, strength, dance sport, resistance training, weight training vibration training.

Selection of the studies

The researchers searched the databases individually by reviewing the titles and abstracts of relevant articles. Relevant titles were those that indicated that the authors studied the effect of a type of supplemental training. Each research had to state that they looked at a certain functional measure for the article to be considered for this review, even though the type of measure and the technique of evaluation varied from study to study.

Inclusion criteria

All articles concerning the introduction of a type of training, other than specific training, in the training of dancers have been included. Articles whose results were compared with another control group or where pre- and post-intervention testing was performed. Initial interest was directed towards dance sport; however few articles were identified that address the issue of fitness training with non-specific means. Thus, to have a solid base of information we also turned our attention to articles that address modern and contemporary dance.

Results

The initial search included 5896 articles (Figure 1). All duplicate articles were eliminated in the first stage (n = 241). Afterwards articles that did not meet the criteria set in the search engines (e.g., articles older than 2000, engineering

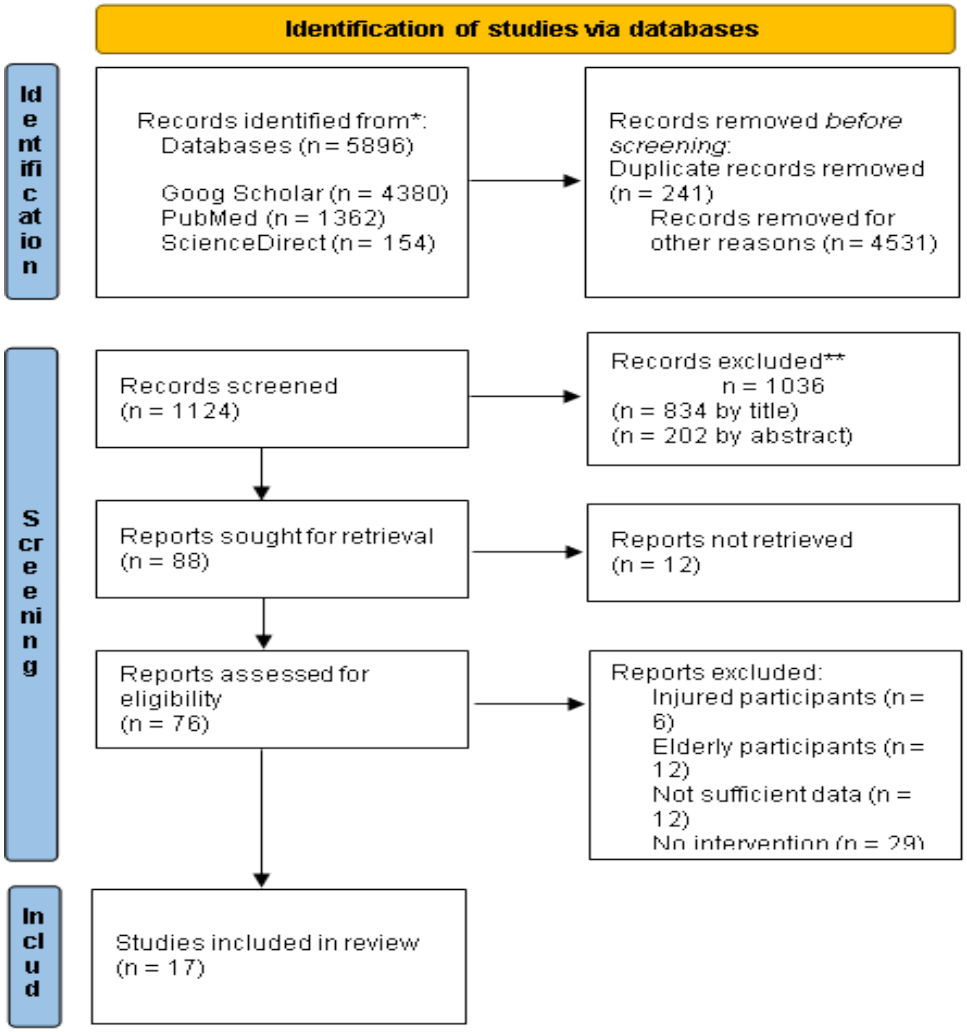

Figure 1. *Prisma diagram for included studies*

or art topic, or newsletters) were excluded (n = 4531). The screening phase included a total of 1124 articles from which 834 articles were excluded by title and 202 articles by abstract analysis. The next step was to search for full text articles to study in full (n = 88). A total of seventy-six articles were assessed for eligibility, of which six were excluded having subjects who suffered injuries. Twelve articles did not provide sufficient information on testing, twelve articles had an elderly population, and twenty-nine articles did not apply any intervention method. The remaining items (17 articles, Table 1) were catalogued according

to the additional training method(s) introduced into the dancers' training. The topics were as follows: resistance training, strength training, Pilates, stretching, plyometric training, aerobic training, or whole-body vibration.

Pilates, stretching and stabilization exercises

To attain balance and body awareness, Pilates is a mental exercise regimen that involves breathing and movement. This workout program is made to be utilized with unique equipment. Particularly among professionals, dancers are probably one of the few that receive Pilates instruction continuously throughout their careers, from childhood to performance or even beyond (Bernardo & Nagle, 2006). Due to its ease of use and low risk of tissue damage, stretching has merged as the most popular technique for improving range of motion (Marshall & Wyon, 2012). It puts pressure on the actin-myosin link, increasing the lengthening of the muscle's inactive components, which in turn lengthens the muscle at rest (Wyon, Smith, & Koutedakis, 2013). The capacity to manage body posture to create proximal stability is referred to as core stabilization. This ensures the transmission and control of force to the distal parts of the body for maximum force generation (Kibler, Press, & Sciascia, 2006).

Ahearn, Greene, and Lasner (2018) conducted research on how additional Pilates exercise (on mat and at apparatus) will influence posture, strength, and flexibility on dancers. After 14 weeks of Pilates exercises done twice a week all the participants had fewer postural misalignments compared to initial testing. Also, their flexibility increased at the level of hamstrings and iliotibial band and strength improved on the lower abdominal muscle ($p < 0.05$).

Kalaycioglu, Apostolopoulos, Goldere, Duger, and Baltaci (2018) combined Pilates training with core stabilization training. At the end of 8 weeks of interventions the authors observed statistical differences for the vertical jump. Dancers' results for posteromedial and posterolateral dynamic balance were significantly different ($p < 0.05$). In this study, in comparison with that made by Ahearn et al. (2018) there was no significant improvement on flexibility at the final testing. Furthermore, the authors observed a significant reduction in peak torque values of left hip flexor muscle group ($p > 0.05$).

In a study realized by Zhang, Ma, Liu, Smith, and Wang (2021), the authors were able to observe that following a 10-week additional training program consisting of static and dynamic balance exercises, participating subjects improved their YBT performance ($p<0.001$). In comparison to the baseline, the experimental group likewise saw a considerable decline in the double-leg floor's average errors at the Modified-Balance Error Scoring System. Also comparing the results of the experimental group with those of the control group, the authors could observe significant differences between them in M-BESS ($p = 0.031$ for tandem floor and $p = 0.038$ for tandem foam).

Pessali-Marques et al. (2020) analyzed the effect of stretching on the hamstrings using EMG assessment. Comparing the effects of constant torque stretching on a group of dancers with those of non-dancers, the authors observed that the former group recorded higher ROM values after the protocol was applied. Additionally, these findings imply that submaximal stretching intensity—defined as the point at which hamstring tension significantly increases—is adequate to promote flexibility in dancers more efficiently than in non-dancers.

Comparing the results of two groups (G1 - low intensity stretching and G2 - moderate-intensity or high intensity stretching), Wyon et al. (2013) observed that both methods produced significant changes in passive ROM. Although the values were close at the time baseline, the final test values were higher for the low intensity stretching group (left leg - 144 ± 22.5 degrees, right leg - 148 ± 14.66 degrees) in comparison with moderate or high intensity stretching group (left leg 133 ± 15,97 degrees, right leg 141 ± 6,72 degrees). Analyzing the results of the active ROM, low intensity group achieved significantly improved values after the application of the training program ($p < 0.05$). In the case of the moderate or high intensity group, although the values were improved (from 76° to 88° for right leg and from 79° to 81° for left leg) differences were not significant after intervention. The authors concluded that low-intensity stretching is preferable than moderate-intensity or high-intensity stretching for enhancing active and passive ROM.

Strength, resistance, and plyometric training

Mistiaen et al. (2012) conducted research where they evaluate physical fitness before and after 6 months of endurance, strength and motor control training on professional dancers. They found that after they participated on the program, dancers significantly improved their aerobic power index, and 75% VO_2 and, decreased their BMI. In contradiction with this finding Roussel et al. (2014) observed no difference on maximal workload, VO_{2max} and standing board jump. In a study realized by Dowse, McGuigan, and Harrison (2017) after nine week resistance training program implementation the subjects involved significantly improved their maximal strength (from 936.54 N to 1092 N, $p = 0.001$). As far as power in squat jump and countermovement jump is concerned, although increases in values were recorded at the time of the final testing, the differences between the means were not significant. However, subjects recorded statistically significant improvements on the subjective evaluation scale in terms of dance performance, control, spatial skills, accuracy and overall performance. In accordance with this study Stošić et al. (2019) found that a 10-weeks exercise program for strengthening the muscles of the torso and legs can improve

significantly explosive power values. They concluded that traditional dance training methods without supplementary exercises lack the extra training stimulus that activities to strengthen the trunk and legs muscles offer.

In a study conducted by Yiannis Koutedakis et al. (2007) they observed that 3-month of aerobic and strength training can improve significantly VO_{2max}, flexibility and strength on left and right leg. The authors found that the control individuals' dance-only training regimen failed to produce any appreciable VO_{2max} alterations by the conclusion of the 12-week observation period. Additionally, it has been shown that cardiovascular adaptations to training rely on its intensity.

Plyometric training methods are used by athletes in various sports to develop their strength and explosiveness. It describes human movement in which an eccentric muscle contraction occurs quickly, followed by a concentric muscle contraction. Plyometric workouts help a muscle achieve its optimum strength as quickly as feasible. Power describes this combination of strength and speed (McNeely & Sandler, 2007).

Kerim, Senem, Kutlu, and Umid (2014) implemented a plyometric training program on a group of 14 dancers for a duration of 6 weeks. At the end of the program, the plyometric training group recorded significantly higher values for vertical jump and peak anaerobic power than the control group. The results of this study demonstrated that plyometric training increased vertical displacement and maximal power production in the countermovement jumping test due to either enhanced motor recruitment or neural adaptations by detecting significant differences for vertical jump and peak anaerobic power. These findings imply that additional plyometric exercises that concentrate on the lower body extremities are advantageous for improving the performance of dancers. The same effect of improving vertical jump height was observed by Brown et al. (2007) who compared the effect of introducing plyometric training and weight training for dancers. Plyometric training group resulted in higher vertical jump and leg press strength scores, whereas weight training resulted in significantly higher leg press, knee curl, and anaerobic mean power scores.

Body vibration training

Exercise research has paid a lot of attention to whole-body vibration (WBV) as a training method (Rehn, Lidstrom, Skoglund, & Lindstrom, 2007).

Wyon et al. (2010) conducted research investigating the changes that occur in vertical jump after exposure to WBV for a period of 6-weeks. Analysis by group showed that throughout the intervention period, the experiment group's jump height significantly increased in comparison to the control groups.

Marshall and Wyon (2012) evaluated subjects on countermovement jump and active range of motion after they followed eight sessions of whole-body vibration training. The intervention group trained twice a week maintaining a strict position for 30 second, in first 2 weeks and 40 seconds in last 2 weeks increasing the frequency of vibration from 35-Hz to 40-Hz. In comparison to the control group, the experiment group had a higher jump height and active range of motion for both legs at the end of the intervention.

Angioi, Metsios, Twitchett, Koutedakis, and Wyon (2012) implemented on their research, on 24 four collegiate female dancers, two methods of training circuit training that concentrated on local muscular endurance and vibration training that focused on power. In their study the control group reported decrements in almost all fitness components except aerobic fitness, while experiment group reported significant increased values for muscular power (11%), upper body muscular endurance (22%) and aerobic fitness (12%) ($p<0.05$).

Table 1. Studies included in the review

Author	Aim	Subjects	Measured parameters	Intervention	Results
Zhang et al. (2021)	To evaluate the efficacy of a ten-week training program on posture	21 couples from ballroom dance	Y-balance test and Modified-Balance error scoring system (M-BESS)	NMT (n=22) and control (n = 20). NMT group – had a ten-week program divided into three phases	NMT group displayed decreased error at M-BESS test ($p<0.05$) and Increased reach at YBT
Kuliś, Sienkiewicz-Dianzenza, and Stupnicki (2020)	To determine the effects of a regular training week cycle spanning six months on dancers' anaerobic endurance	8 couples of different dance styles aged 14-26 year performed	The group performed 8 sprints on 50m distance with 15 second recovery using a Polar Heart rate monitor	The group followed a weekly cycle training with 5 training	Velocities were improved at the final test result for both male and female subject ($p< 0.005$)
Pessali-Marques et al. (2020)	This study attempted to compare dancers to non-dancers in terms of how their hamstring muscles responded biomechanically to acute stretching	46 young males, 23 undergraduate students (ND) and 23 professional dancers	During each passive knee extension EMG analysis was conducted	Each participant had used the Knee Extension Test Device (KETD)	The torque and range of motion was greater on dancers then non dancers

Author	Aim	Subjects	Measured parameters	Intervention	Results
Stošić et al. (2019)	The purpose of this study is to examine how a ten-week modern and recreational dance training program, as well as exercises to strengthen the trunk and legs, affect the coordination and explosive power of female dancers in the student age group	54 subjects were assigned, of which 27 made up the experimental group who participated in an experimental exercise program and 27 the control group	Based on six tests, the participants' coordination was assessed (Side Steps, 20 Steps forward Twirling a Baton, Skipping the Horizontal Jump Rope, Turning in 6 squares, Hand-Foot Drumming and Agility test with a Baton)	The experimental group performed Hip Hop and Dancehall dances and trunk and leg muscle strengthening exercises 3 times a week for 90 min each. The control group had no additional forms of exercise other than regular daily activities	Results revealed statistical significance between the groups for two variables of explosive power at the univariate level ($p<0.05$) and five variables of coordination at the multivariate and univariate levels ($p<0.05$, $p<0.01$).
Ahearn et al. (2018)	This study aims to investigate the qualitative and quantitative benefits of Pilates training on pelvic alignment, strength, and flexibility in dancers	Twenty female dancers, aged 17 to 22	The subject underwent an AlignaBod posture screening, upper abdominal manual muscle test, double leg lower test, straight leg raise test, and modified Thomas test as part of the screening. Participants underwent screening, took part in dancing courses for 14 weeks without interruptions, and underwent screening again.	They attended a two-hour session on pelvic alignment, followed by 14 weeks of two weekly Pilates lessons, one on the mat and one on the equipment	No differences were shown between screening 1 and screening 2. Statistically differences were obtained between screening 2 and screening 3 when Pilates classes were introduced into training
Kalaycioglu et al. (2018)	The purpose of this study was to investigate at the way a core stabilization training (CST) program affected the ballet and contemporary dance performances of college-level dancers.	The research included twenty-four dancers between the ages of 18 and 24	Physical fitness parameters were evaluated such as vertical jump performance, flexibility, dynamic balance, coordination, proprioception, muscle, and hip flexion isokinetic strength measures	During eight weeks, core stabilization exercises were done for 45–60 minutes a day, three days a week	After CST statistically significant differences were observed on vertical jump, peak torque and hip flexor muscle

Author	Aim	Subjects	Measured parameters	Intervention	Results
Dowse et al. (2017)	The purpose was to determine how nine-week resistance training will affect lower body strength	12 dancers performing ballet and modern dance	Anthropometry measurement, Biodex Balance System assessment, countermovement and squat jump, isometric mid-thigh pull	Nine-week training program with two sessions each week including resistance training exercises	Significant differences were observed at peak torque and countermovement jump and squat jump
Kerim et al. (2014)	In this study, female college contemporary dancers' peak anaerobic power and vertical leap were examined in relation to plyometric training.	27 contemporary modern dancers were divided into two groups: the plyometric training group (n = 14) and the control group (n = 13)	Countermovement jump was used to assess vertical jump height and to calculate peak anaerobic power	Experimental group performed 2 sessions of plyometric training	Significant statistically difference was seen on both peak anaerobic power and vertical jump height
Roussel et al. (2014)	The purpose of this study was to observe if any supplemental training will improve aerobic capacity and explosive strength	44 Pre - professional dancers divided into two groups (Group A which received a conditioning program and Group B that received a health promotion program)	Subjects were determined BMI, aerobic capacity with electronically braked bike ergometer and standing broad jump	Group A fallowed a conditioning program with aerobic, strength and motor control training, and Group B had no other training regime	Supplementing training sessions with a conditioning program had no significant improvement on subjects
Wyon et al. (2013)	Was to assess the effect of 3 strengthening or stretching intervention on hip and lower limb	39 female dancers were randomly divided into three groups (G1 – strength training n=11, G2 – low intensity stretching n=13 and moderate intensity or high intensity stretching n=11)	All subjects were tested regarding active range of motion (AROM) and passive range of motion (PROM)	All groups fallowed a 6-week intervention as suggested by their specific target	Regarding PROM there was not observed any statistically differences between group. For AROM strength and low intensity stretch groups revealed significant improvement compared with moderate intensity or high intensity stretch group

Author	Aim	Subjects	Measured parameters	Intervention	Results
Angioi et al. (2012)	The purpose of these study was to observe the effect of supplemental training on fitness of contemporary dancers	21 female contemporary dancers were assigned into two groups (Exercise n = 12 and control n = 9)	Subjects were evaluated for body composition, muscular power, muscular endurance, and aerobic capacity	The exercise group performed twice a week one hour of circuit and vibration training	Control group registered decreased values on all fitness parameters. Exercise group revealed significant increased values
Marshall and Wyon (2012)	The purpose of this study was to investigate at how 4 weeks of WBV affected students studying classical dance in terms of jump height, active range of motion (AROM), and leg anthropometry	117 female dancers were random divided into control and intervention groups	Subjects performed a countermovement jump using Just Jump mat and AROM was assessed using a digital camera	Experimental group trained using WBV for 30 seconds position at 35Hz for 2 weeks and 40 seconds for other 2 weeks at 40Hz whereas control group caried normal exercises	AROM and jump height was significant improved for experimental group
Mistiaen et al. (2012)	The aim of this study was to assess the musculoskeletal injury rate and physical fitness in preprofessional dancers before and six months following an exercise program for endurance, strength, and motor control.	40 preprofessional dancers (38 females and 2 males)	A field test for explosive strength and a submaximal exercise test with continuous physiological monitoring were both used to assess physical fitness. To examine how fitness training affected body composition, anthropometric measures were obtained.	6-month supplemental training consisting in aerobic endurance exercises and local strength endurance	Physical fitness improved after the 6 months of additional training program ($P < 0.05$)
Lukić, Bijelić, Zagorc, and Zuhrić-Šebić (2011)	The purpose of this study was to show the importance of strength training on dancers' performance	49 sport dancers (25 female and 24 male)	Testing protocol consist in upper body lifting, throwing medical ball from laying down and jump from the spot		

Author	Aim	Subjects	Measured parameters	Intervention	Results
Wyon et al. (2010)	The purpose of this investigation was to determine how exposure to WBV training over a 6-week period affected vertical jump.	18 females undergraduate dance majors	Authors measured jump height, calf, and thigh circumference	The control group had a comparable isometric contraction stress whereas the intervention group underwent WBV at 35 Hz for 5 minutes twice weekly.	The results showed that the vertical jump height increased considerably ($p < 0.05$) more in the intervention group than in the control group following a 6-week intervention.
Brown et al. (2007)	The main purpose was to examine resistance training in comparison with plyometric training	18 female dancers	Authors assessed height of vertical jump and jump ability	The group was divided into three small groups (Plyometric n = 6, weight n=6 and control n=6)	No significant changes were observed for control group. Instead, it was observed improvement in jump height for the other two groups
Yiannis Koutedakis et al. (2007)	The aim for this study was to assess the effects of 12 weeks aerobic and resistance training	27 females' dancers and 5 male dancers	Authors measured body mass and technical dance measurement (TDM)	The group was divided into two: experimental who carried free weight training and control who practiced only dance	There was observed increased values of TDM for experimental group ($p<0.05$)

Discussions

In our study we tried to collect the most relevant studies that address the topic of physical training. As far as we know there are few publications that address physical training in this area.

According to some reports, dancers are afraid that doing ST will make their muscles bigger and compromise their bodies' ability to maintain the necessary beauty (Yiannis Koutedakis et al., 2007; Twitchett et al., 2009).

In their research Farmer and Brouner (2021) tried to find the perception of dancers about strength training. Although there is a fear in this category of athletes from their study it could be observed that both professional dancers and students totally agreed that strength training is essential for their performance. Their findings imply that, in contrast to teachers, dancers are aware of the

potential advantages of strength for both men and women and feel that it is crucial to their entire training. It has been suggested that the dance studio should maintain its current concentration on technique, artistry, and performance aesthetics, with conditioning taking place in distinct sessions. The function of dance teachers is primarily focused on technique, artistry, and performance aesthetics. The findings show that teachers do not promote ST to the same extent that dancers do, and they do not see the development of physiological traits like strength as being crucial to a dancer's growth.

In a review made by Girard, Koenig, and Village (2015) they found that the variety of ways the intended effect may be obtained when strength training with resistance is an advantage. In general, free weights, weight machines, kettlebells, etc., may be found in fitness centers, member gyms, and university gyms without a significant cash outlay. There are several strength training programs available that may easily fit into a dancer's schedule, and if the fundamentals of exercise technique are mastered, using weights, kettlebells, or machines on your own is simple. For dancers, strength training using free weights, machines, or kettlebells is a realistic choice.

Some of the articles collected gave us information on improving physical parameters such as strength, power or aerobic endurance.

Strength, resistance training, and plyometric training has been found to increase vertical jump height in countermovement jump or squat jump (Brown et al., 2007; Dowse et al., 2017; Kerim et al., 2014).

Strength training is positively correlated with improved subjective dance performance compared to non-strength training control groups in all studies that assessed the impact of strength training on a subjective dance performance measure. Although it is unlikely that strength training directly affects dance technique, it is logical to think that increased strength may give the dancer a stronger base from which to develop. Instead of concentrating on their ability to finish the movement, the dancer may be able to concentrate on improving their technique and artistry as a result.

It is not yet clear whether WBV can really help dancers in their training. Although some studies have analyzed the results and shown that the final measurement values have been improved Delecluse, Roelants, and Versheruen (2005) observed that there was no significant changes on jump performance, knee extensor and knee flexor strength. However, studies addressing WBV have shown that research participants have improved their active range of motion.

There is little evidence supporting Pilates' efficacy, and this scant evidence is due to the use of questionable research methodologies in the published studies. Researchers and practitioners believe that there needs to be more published research on the effectiveness of Pilates in both healthy and injured individuals

(Bernardo & Nagle, 2006). However, the research analyzed in this review showed that dancers who additionally practice Pilates record significantly improved values in terms of range of motion, height of vertical jump and peak torque on hip flexor.

Conclusions

The lack of studies carried out to determine the effect of introducing an additional form of training in the training of dancers is the reason for this research. Research on subjects needs to be carried out to determine the effects of different methods and practices.

The effectiveness of various training programs could be ascertained through well-designed studies that randomly assign subjects, use a control group, measure compliance with the study intervention, include covariates in the statistical outcomes, calculate power, and use valid and reliable methods to measure outcomes.

The scientific foundation of many skills developed and used in the dance profession can only be strengthened by such study.

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