OULUN AMMATTIKORKEAKOULU

DANCERS’ JOURNEY TO HIGHER JUMPS

A Self-Study Using Scientific Research and Data

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Bachelor’s Thesis
Spring 2025
Bachelor of Culture and Arts
Oulu University of Applied Sciences

ABSTRACT

Oulu University of Applied Sciences
Degree Program in Bachelor of Culture and Arts
Option of: Show Dance

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Title of thesis: Dancers’ Journey to Higher Jumps
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Thesis submitted: Spring 2025
Number of pages: 66

This self-study thesis investigates the impact of short supplementary training on dancers' performance, specifically focusing on jump height and aesthetic improvements. The primary objective was to determine whether integrating specific strength and conditioning exercises could enhance dancers' jumps more effectively than traditional dance training alone.

Utilizing scientific research and data, an effective and comprehensive training program was developed and conducted, targeting a wide range of muscles and applying various types of loads to improve jump height and control during jumps. The program incorporated diverse training methods, including resistance training, force-velocity imbalance (F-Vimb), plyometric training, neuromuscular training (NMT) with a hip-dominant focus, whole-body vibration (WBV), and jump rope.

Over a two-week trial period, qualitative improvements were observed and documented in various aspects of performance. These included alignment, proprioception, muscle awareness, turnout, mobility, coordination, flexibility, strength, balance, stamina, fluidity of movements, better control during jumps and aesthetic enhancements.

The findings suggest that the inclusion of task-specific supplementary training can enhance neural connections and coordination, leading to quicker improvements in performance. This approach can help dancers develop high-level performance skills faster, making it a valuable strategy for those seeking to enhance their jump height and overall athletic and dance performance.

Therefore, dance schools should consider integrating structured, task specific, well-rounded strength and conditioning programs into their curriculum, potentially in collaboration with physical therapists or certified trainers. This approach can accelerate dancers' development, reduce injuries, enhance aesthetics, maximize potential, and extend dance careers.

CONTENTS

1 INTRODUCTION

Dancers face unique challenges, including overtraining and overscheduled training seasons that prioritize dance training and skill acquisition over physical conditioning. As a result, many dancers find themselves inadequately prepared to meet the rigorous demands of their performances, especially the vertical jump height, which is a critical performance metric in dance, reflecting explosive power and neuromuscular efficiency. Ngo et al. highlight that discrepancies between technical abilities and physical fitness can lead to potential physical issues, such as a higher risk of injury in the hips or lower extremities, dance-related aches or pains, and an inability to achieve high levels of physical fitness and performance, ultimately impacting dancers' aesthetic competence (Ngo, Lu, Cloak, Wong, Devonport & Wyon 2024, 637 - 652).

While elite athletes often use targeted, time-efficient methods like plyometrics and contrast training, their applicability to non-elite populations remains underexplored. This paper aims to identify the key components of scientific research and data about conditioning interventions and explore how these methods can be integrated into a dancer's regimen to enhance lower limb strength and achieve greater elevation and power in jumps. My research focuses on short-term and effective strength and conditioning methods, including whole-body vibration, plyometric training, F-Vimb, resistance training, neuromuscular training, and jumping rope.

To address these challenges, I created a 2-week training trial, derived from scientific research and data to improve jump height. Documented in an experiential style, this trial aims to enhance physical parameters and evaluate how short-term, efficient training can be integrated into existing dance teacher student training program, assessing its suitability and effectiveness.

Thesis Statement: This paper will demonstrate that integrating task-specific, targeted, and time-efficient conditioning methods from scientific research programs into dance training can offer substantial benefits and enhance a dancer’s overall performance and technical abilities.

2 METHODS

This chapter outlines the methodologies employed in this study to investigate the physical attributes and conditioning methods that influence jump performance in dancers. It is divided into two main sections: evaluation of common fitness methods in dance, and effective alternatives for improving jump height.

The EBSCOHOST database was searched to identify eligible studies on dancers' strength and conditioning methods that affect positively on jump height. By analyzing high-quality, peer-reviewed studies from the EBSCOHOST database, I sought to identify reliable and credible techniques that can enhance dancers' jump height. To examine this research topic, I included both randomized and non-randomized trials and did not assess the methodological quality of included trials.

2.1 Evaluation of common fitness methods in dance

According to Escobar Alvarez et al. (2019), the standardized training regimen for elite dancers includes rehearsal, technique, Pilates, Gyrokinesis, Gyrotonic, and cardiovascular training. (Escobar Alvarez, Fuentes Garsia, Da Conceicao & Jimenez-Reyes 2019, 788–794.) Although Gyrotonic and Gyrokinesis are integral to many elite dancers' training regimens, I have not found any research on EBSCOHOST about them, regarding their impact on improving jump height in the dance population.

While the Pilates method is very popular among dance populations, research indicates that only nine studies used Pilates as an intervention for dancers between 1980 and 2015. According to Bergeron's systematic review, based on the limited results of these nine studies, Pilates is effective for improving muscular strength and flexibility but appears to be ineffective in increasing vertical jump and balance in dancers (Bergeron, Greenwood, Smith & Wyon 2017, 66–77).

Therefore, my study will exclude training methods such as Gyrotonic, Gyrokinesis, and Pilates, as there is no evidence confirming their positive impact on jump height. Instead, the focus will be on identifying effective and short-term interventions specifically designed to improve jump height.

2.2 Effective alternatives for improving jump height

While research specifically targeting dancers' jump height using different training modalities is limited, I decided to study sport science and elite athletes' training methods, including studies on dancers that focus on jump height. My goal was to create a diverse training system tailored to my needs and effectively target specific objectives. I found support for my theory in the study by Ngo et al., which states that utilizing combined training—incorporating multiple training modalities into athletes' programs—significantly improves jumping and overall performance (Ngo et al. 2024, 637–652). Long also proposes that by applying principles of sports science to professional dancers' training regimens, dance performance can be improved, and injury risk decreased. (Long, Milidonis, Wildermuth, Kruse & Parham 2021, 404–417.)

I found several studies indicating that neuromuscular training, resistance and plyometric training, whole-body vibration, and jumping rope training can enhance jump height. These methods are well-regarded among athletes for their effectiveness in improving jump height and are known as short-term interventions. By integrating these techniques, I anticipate significant improvements in my performance.

3 PHYSICAL ATTRIBUTES FOR JUMPS

Ngo et al. remarks that achieving high jumps requires a combination of physical attributes, including lower body power, upper and lower body strength, and flexibility (Ngo et al. 2024, 637–652). Lower body power is crucial for generating explosive force, while upper and lower body strength helps maintain balance and control. Flexibility is necessary for achieving full extension in jumps.

Additionally, Jimenez-Reyes highlights that ballistic movements, such as sprints, changes of direction, and jumps, rely on high levels of force, power, and velocity (Jimenez-Reyes, Samozino & Morin 2019, 1–20). These physical qualities highlight the need for an ideal balance between force and velocity to achieve more powerful and higher jumps. Therefore, targeted strength and conditioning (SC) interventions focusing on lower body power, lower and upper body strength, and improving the balance between force and velocity can enhance jump performance.

3.1 Force-Velocity Profile

According to Escobal Alvarez et al., recent findings and field methods in ballistic actions have highlighted the importance of measuring the relationship between force and velocity mechanical capabilities during jumping performance, known as the force–velocity profile (F-V profile) (Escobar Alvarez et al. 2019, 788–794).

Escobar Alvarez et al. explains that quantifying the actual and optimal F-V profile highlights the individual needs of each athlete, determining if the improvement of either force (force deficit) or velocity (velocity deficit) capabilities is required to enhance jump performance while reducing the actual F-V imbalance (Escobar Alvarez et al. 2019, 788–794).

The force-velocity profile is crucial for grasping how muscle force and contraction speed are interconnected. This understanding aids in creating specific strength and conditioning programs to enhance jump performance. By boosting both force and speed, dancers can achieve more dynamic and higher jumps, which are vital for different dance styles and routines.

3.2 Lower body power

Lower body power is often considered one of the most important physical attributes for dancers as jumping is an integral part of most dance performances. Powerful leg muscles not only help in achieving higher jumps but also in maintaining control and balance during performance.

In a systematic review by Ngo at al. on strength and conditioning in dance, eleven studies examined the effect of strength conditioning (SC) on lower body power, utilizing various SC intervention modalities including resistance training, plyometric training, whole- body vibration, and combined training. Ngo et al. emphasize that the effects of these strength and conditioning methods suggest they can be effective tools for improving jump performance (Ngo et al. 2024, 637–652).

3.3 Upper and lower body strength

Four studies examined the effects of SC and found that interventions targeting both areas led to significant improvements. Ngo et al. remarks that a systematic approach to SC can greatly enhance muscular strength in dancers (Ngo et al. 2024, 637–652).

In the research, Ngo explains that upper body strength in dancers increased through resistance training programs that used progressive loads, likely due to neuromuscular adaptations. Lower body strength was improved through plyometric training. Research found that plyometric training led to similar strength gains as resistance training, but with better results. SC programs included exercises like leg press, leg curl, calf raise, step-ups, and depth jumps, focusing on the hamstrings, quadriceps, and calves. Therefore, resistance and plyometric training interventions can lead to improvements in leg strength without interfering with key artistic and physical performance requirements in dance. (Ngo et al. 2024, 637–652.)

3.4 Flexibility

Four studies investigated how strength conditioning (SC) affects flexibility. They found that plyometric training and whole-body vibration training had moderate to large positive effects on flexibility, while resistance training did not improve flexibility. (Ngo et al., 2024, pp. 637–652.)

Among various conditioning methods, combined training significantly enhanced the range of movement. Additionally, whole-body vibration specifically improved the active range of hip movement. Therefore, Ngo et al. comments that whole-body vibration could serve as an additional training method with benefits similar to plyometric or resistance training for dancers (Ngo et al., 2024, pp. 637–652).

4 STRENGHT AND CONDITIONING

Although the principle of specificity in sport is well-documented and widely accepted, specific dance training (e.g., dance classes or dance-specific training) alone cannot boost dancers' jump height and therefore should not be the sole training method for dancers. Given the unique demands of the dance and the purported benefits of specificity, along with the high daily training loads dancers endure, Trecroci at al. suggests that training program should be a combination of general physical activities and dance-specific exercises. (Trecroci, Cavaggioni, Caccia & Alberti 2015, 792–798.)

Strength and conditioning (SC) is a widely used training modality across various sports. Therefore, integrating strength and conditioning may be crucial to bridging the physiological gap between training and performance in the dance population as well. A systematic review and meta-analysis by Ngo et al. found that incorporating additional supplemental training sessions into dancers' programs, regardless of the modality, can enhance their fitness levels to better meet the physical demands of technical training, artistic expression, and overall stage presence (Ngo et al. 2024, 637–652).

According to Ngo et al. additional physical training such as resistance training, plyometric training, whole body vibration training, and combined training are the most common strength and conditioning (SC) interventions in sport and are found effective at improving some physical qualities in dancers such as large effects on improving lower body power, upper body strength, lower body strength, and flexibility. (Ngo et al. 2024, 637–652.) These qualities are crucial for achieving high jumps in dance.

A study by Escobar Alvarez et al. confirms that both plyometric training and traditional weight training have a positive effect on strength, power, and jump height in dancers. (Escobar Alvarez et al. 2019, 788–794.) Long et al. also suggests that implementing a neuromuscular conditioning program can improve function, balance, hop distance, stability, and upper extremity performance (Long et al. 2021, 404–417).

4.1 SC as an Injury prevention

Dance training, particularly the extensive amount of jumping, may contribute to the high rate of musculoskeletal injuries among professional ballet dancers. According to Sudds et al., 70% to 80% of pre-professional dancers experience an injury each year (Sudds, Maurus, Nigg, Wyon & Kolokythas 2023, 139–152). Kolokythas et al. point out that most injuries in both pre-professional and professional dancers primarily affect the lower limbs. Research on injury prevention in sports indicates that strength and conditioning (SC) interventions can reduce injury risks by 30% to 50% (Kolokythas, Metsois, Galloway, Allen & Wyon 2022, 181–190).

As injury prevention and optimizing performance are key considerations in both athletics and dance, alongside the strengthening SC interventions, Sudds suggests that dancers may benefit from neuromuscular training, an injury prevention exercise program that has been successfully implemented in other sports. (Sudds et al. 2023, 139–152).

4.2 Tailored SC programs for dancers

It's crucial to customize strength and conditioning (SC) programs to fit each dancer's unique choreographic works, dance styles, and personal goals. For me, prioritizing lower body strength, improving high jumps, and enhancing physical attributes like power, strength, and flexibility is vital. Training should be multifunctional, diverse, short, and effective.

Therefore, I will investigate SC methods such as neuromuscular training, plyometric and resistance training, and whole-body vibration (WBV) - interventions specifically targeting high jumps. I hypothesize that this study will improve jump performance, resulting in more dynamic and captivating dance routines.

5 NEUROMUSCULAR TRAINING

Neuromuscular training (NMT) programs have been effective for improving performance measures, such as jump height, and lower extremity landing biomechanics. Sudds et al. broadly describes neuromuscular training as multifaceted exercise programs that combine strength, balance and proprioception, resistance training, agility, plyometrics, and sport-specific exercises. Additionally NMT aims to enhance speed, reaction speed, coordination, and endurance among athletes (Sudds et al. 2023, 139–152).

According to Zhang et al., NMT is purported to be effective for the rehabilitation of sports injuries and, when used as a warm-up, for the prevention of lower limb injuries. This is due to its unique capacity to provoke physiological sensory feedback alterations, thereby enhancing joint functionalities. NMT also improves sports performance in various physical fitness components, including jumping, abdominal endurance, and postural control (Zhang, Ma, Liu, Smith & Wang 2021, 636209).

5.1 Neuromuscular Warm-up

Kaufmann et al. highlights that an important injury prevention measure could be an appropriate warm-up. In sports science, neuromuscular (NM) sport-specific warm-up has been shown to prevent injuries. This warm-up targets the athlete’s proprioceptive and sensorimotor abilities, strength, and power without engaging in technical drills. Kaufmann et al. points out that neuromuscular warm-up specifically enhances the joint position sense (proprioception) and balance as well as anticipatory and compensatory reflexes relevant for protection of joints in dynamic stability. This reduces injury risk, especially to the lower limbs, which is the most affected anatomical location in dancers (Kaufmann, Nelissen & Gademan 2022, 244–254).

Neuromuscular program is based on a variety of exercises grouped into exercise sets that target the overall aspects:

1. General warm-up: jogging or running for 5 to 10 minutes.
2. Specific warm-up: strength and core stabilization exercises
3. Sensorimotor and proprioceptive training: enhancing abilities in both static and dynamic movements.
4. Cardiovascular stimulus: longer duration exercises supported by continuous activity designs (Kaufman et al. 2022, 244–254).

Neuromuscular programs such as FIFA 11+ were developed as early as 2006. These programs have been effective in reducing the risk of injury in athletes by decreasing the moments surrounding the knee and improving neuromuscular control during static and dynamic movements such as jumping and landing (Sudds et al. 2023, 139–152).

Neuromuscular training, such as the 11+ Dance, is an adapted version of the FIFA 11+ football injury prevention program. This low-intensity workout lasts about 20 to 30 minutes and includes dynamic bodyweight exercises designed to prevent injuries, based on scientific evidence and best practices. Supported by numerous high-quality research studies, Sudds suggests that the simplicity of the 11+ Dance could be a practical and advantageous addition to regular warm-ups in dance practice (Sudds et al. 2023, 139–152; Kolokythas et al. 2022, 181–190).

5.2 Hip dominant NM

Because of the artistic demands of dance, half of all jumps are performed with single-leg landings. Kolokythas states that some larger jumps, like the grande jeté, can create forces on the knee that are more than 12 times the dancer's body weight. (Kolokythas et al. 2022, 181–190.) This makes jumping in dance one of the most challenging and risky aspects, especially for the knee. Therefore, interventions that reduce stress on the knees should be highly valued and implemented.

A study by Sudds et al. (2023) proposed that hip dominant neuromuscular training could be used to increase moments at the hip while reducing moments at the knee. This method decreases stress and strain on the knee joint, which helps lower the risk of knee injuries. It not only reduces injury risk but also enhances jump performance. Overall, Sudds's findings indicate that adjusting the angles and forces on the knee and hip joints can minimize the risk of both acute and overuse injuries (Sudds et al. 2023, 139–152).

In the study, Sudds found that the 11+ Dance intervention group reduced knee moments and increased hip moments during takeoff compared to the control group. Sudds states that when the 11+ Dance is performed twice per week for 8weeks, it may induce biomechanical adaptations resulting in prophylactic effects on overuse injuries. (Sudds et al. 2023, 139–152.) In the Table 1, I present the exercises for 11+ Dance program, used in the trials for hip-dominant neuromuscular training (Kolokythas et al. 2022, 181–190; Sudds et al. 2023, 139–152).

TABLE 1. Exercises from 11+ Dance (Kolokythas et al. 2022, 181–190; Sudds et al. 2023, 139–152)

Static exercise duration: 10-15seconds. Dynamic exercise repetitions: 6-12 each side. Sets: 1-2.	
- Plank on elbow – raise the leg - Plank on hands – raise the leg - Side plank – on knee - SL bride and hold - Hamstring raises - Squats to releve - Walking lunges - Side lunges - SL balance – hip rotation - SL balance – upper body rotation - Cross-country skiing - Hip airplane - Forward landings - SL Forward landings	- SL lateral landings - Plank on hands with elbow taps - Bear walk – static 3 point contact - Crab walk – static 3-pont contact - Cook hip lift - 4-way monster walks – straight legs - 4-wat monster walks – bend legs - Squats with overhead reach - Side slides - Leg swings forward - Leg swings cross-body - SL reach - Side landings

5.3 Training load

Long et al. state that implementing a neuromuscular conditioning program improved function, balance, hopping distance, stability, and upper extremity strength. However, many of the improvements observed were not sustained at the four-month follow-up. This indicates that continuous conditioning is necessary to maintain peak physical performance. (Long et al. 2021, 404–417.)

Kolokythas et al. suggests that the frequency of the neuromuscular workout should be two to three times per week, depending on the training sessions the participants have in the week. (Kolokythas et al. 2022, 181–190) Therefore, aiming to improve performance I will include neuromuscular, hip dominant warm-up routine as a part of 2 training session per week for my trial.

6 RESISTANCE TRAINING

It has been identified that dance training alone does not adequately prepare dancers physically for the demands of performance. Dancers must possess exceptional physical competence, coordination, flexibility, strength, and balance to perform at a high level. (Brown, Wells, Schade & Smith 2007, 38–44.)

Dowse observes the significance of resistance training in the development of dancers and the enhancement of their physical and aesthetic performance. A study demonstrated that a 9-week resistance training program can significantly improve certain physiological parameters and has a significant effect on maximum lower-body strength and power, dynamic balance, and dance performance in adolescent dancers. Therefore, Dowse et al. emphasizes that incorporating resistance training is crucial for bridging the gap between training and performance demands, addressing musculoskeletal deficiencies, and enhancing key performance aspects such as jumping ability (Dowse, McGuigan & Harrison 2020, 3446–3453).

Ballerinas who participated in a 12-week resistance training program experienced significant improvements in strength and their capacity to generate force, even after exhausting dance routines. The results also revealed that less experienced or weaker dancers benefited more from the structured resistance training, showing greater positive responses and gains. (Dowse et al. 2020, 3446–3453.)

6.1 Exercises for resistance training

Dowse, in her study on the effects of a resistance training intervention on strength, power, and performance in adolescent dancers, examined a 9-week resistance training program. Program involved two sessions each week: one lasting 45 minutes and the other 60 minutes. The number of exercise sets and repetitions increased as the study progressed. The equipment used included therapy bands, dumbbells, barbells, and power bags. Before each training session, the subjects followed a standardized general and dynamic warm-up consisting of skipping, leg swings, hip internal and external rotations, hip hinges, scorpions, and transverse abdominis activation. (Dowse et al. 2020, 3446–3453) The exercises for the resistance training, used in the Dowse's trial, are detailed in the Table 2.

TABLE 2. Resistance training exercises from the Dowse's trial (Dowse et al. 2020, 3446–3453)

Sets: 2-4. Repetitions: 3-20. Rest between the exercises 60s-180.	
- SLRDL	- Plank complex
- Split squat	- DB twist
- Bulgarian split squat	- Deadlift
- Bent-over row	- Hip thrusts
- Push up	- Explosive power bag pulls
- squat walk with therapy band	- Clapping pushups
- Plank	- Depth jumps
- Straight arm plank	- Lunge jump

6.2 F-Vimb methodology

Studies show that one of the useful variable for prescribing optimal resistance training to improve jumping performance is *F-Vimb* (force and velocity imbalance) methodology. (Escobar Alvarez et al. 2019, 788–794.) Escobar Alvarez states that the training programs aimed at reducing the current *F-Vimb* are more effective in improving jumping performance than traditional resistance training that is common to all individuals, regardless of their actual and optimal F-V profiles. (Escobar Alvarez et al. 2019, 788–794.)

Jimenez-Reyes asserts that each individual has an optimal force-velocity (F-V) profile that maximizes ballistic performance, such as vertical or inclined jumping. This profile represents the ideal balance between force and velocity attributes during jumps (Jimenez-Reyes et al. 2017, 677).

Study confirms that an optimized and individualized training program specifically addressing the force-velocity imbalance effectively enhances jumping performance. Escobar Alvarez et al. emphasizes that the *F-Vimb* can be considered as a potentially valuable variable for prescribing optimal resistance training to improve ballistic performance, such as jumping and countermovement jump (CMJ), in female ballet dancers, surpassing traditional resistance training methods. (Escobar Alvarez et al. 2019, 788–794; Jimenez-Reyes et al. 2019, 1–20.)

In the studies by Escobar Alvarez et al. (2019) and Jimenez-Reyes et al. (2019), the low force-deficit (LFD) and high force-deficit (HFD) subgroups performed specific exercises tailored to their respective groups. I gathered the exercises from both studies, combined them, and grouped them into the LFD and HFD categories. Table 3 outlines the strength training programs for each subgroup, which I compiled using exercises from two separate studies.

TABLE 3. Exercises for the LFD and HFD subgroups (Escobar Alvarez et al. 2019, 788–794; Jimenez-Reyes et al. 2017, 677.*)*

Each exercise 3 sets / 6 repetitions	
LFD (low force-velocity deficit)	**HFD (high force-velocity deficit)**
- leg presses, - squat jumps, - single-leg CMJs - back squats, - CMJs, - SJ (squat jumps) - Deadlift	- leg presses, - squat jumps, - single-leg CMJs, - back squats, - CMJs, - single-leg SJ (squat jumps) - Deadlift - Clean Pull

In the study by Jimenez-Reyes et al. (2019), the force deficit (FD) group showed significant improvements from the heavy-load program. They experienced large increases in force, reduced force-velocity imbalance (F-Vimb), and higher jump heights. All subjects improved their jump height beyond the smallest worthwhile change, confirming the effectiveness of this training approach. (Jimenez-Reyes et al. 2019, 1–20.)

Jimenez-Reyes et al. (2019) found that the level of improvement varied when comparing the velocity and force deficit sub-groups; the velocity-deficit sub-group tended to almost reach the optimal profile in the fixed 9-week training period, while the force-deficit sub-group were not as close to the optimal profile. Jimenez-Reyes suggests that structural adjustments, primarily related to force, likely require more time compared to the immediate neuromuscular adaptations associated with both force and velocity. (Jimenez-Reyes et al. 2019, 1–20.)

My personal force-velocity (F-V) profile is HFD. Therefore, I will use exercises from the studies to improve my HFD. However, using the force-velocity approach to enhance my ballistic performance and reduce force deficits, a fixed trial duration of 2 weeks will be insufficient to achieve my optimal profile. According to Jimenez-Reyes, achieving the optimal profile for HFD requires approximately 15.9 ± 3.8 weeks. (Jimenez-Reyes et al. 2019, 1–20.)

Therefore, given my limited 2-week trial period, I will concentrate exclusively on the training content, how this additional intervention will be integrated into my schedule, and strategies for successfully continuing training after the trial.

Jimenez-Reyes at al. (2019) found that after stopping the specific training once an optimal F-V profile was reached, training-induced adaptations remained unchanged overall during the 3-week period following the cessation of specific, individualized training. (Jimenez-Reyes et al. 2019, 1–20.) Consequently, I conclude that for dancers who want to periodize training and include additional training sessions (to improve jump height) in busy schedules, this training method will be very effective.

7 PLYOMETRIC TRAINING

Girard states that strength and plyometric training have proven effective in enhancing athletic performance. It is anticipated that these physiological mechanisms will similarly benefit dancers, improving their performance (Girard, Koenig & Village 2015, 233–240). Plyometric training have shown a positive effect on strength, power, and jump height in dancers (Escobar Alvarez et al. 2019, 788–794). It has been proven to increase jump height, and there is some indication that it may also enhance horizontal jump performance, such as a grande jeté in dance, although research in this area is limited. (Armstrong, Bergeron & Boucher 2018, 37–44.)

Dowse explains that plyometric exercises enhance explosive power by training the muscles to exert maximum force in short intervals. For example box jumps, depth jumps, and bounding. Due to the demanding nature of plyometric exercises, the National Strength and Conditioning Association (NSCA), recommends that these exercises should not exceed 6–8 repetitions and that the focus should be on fewer quality repetitions. (Dowse et al. 2020, 3446–3453.)

I found two studies on dancers' jump height that utilized exercise protocols based on a plyometric approach. Brown's study included four exercises, while Armstrong's study had a series of increasingly difficult, dance-specific exercises. Both studies showed positive effects on jump height. (Brown et al. 2007, 38–44; Armstrong et al. 2018, 37–44.)

Brown et al. examined the effects of 6 weeks of plyometric training versus traditional strength training on power and aesthetic jumping ability in collegiate dancers. All participants were considered novices to plyometric training and were prescribed four exercises of low to medium intensity with a low volume of total touches. The plyometric training protocol consisted of 3 sets of 8 repetitions, with a one-minute active recovery period between sets during which the subjects walked casually (Brown et al. 2007, 38–44).

Armstrong et al. examined the effectiveness of dance-based plyometric training on dancers' vertical and horizontal jump performance. The trial lasted 5 weeks, during which the intervention group performed a series of exercises that increased in difficulty and became more dance-specific as the study progressed. Participants were instructed to complete as many repetitions of each exercise as possible within 20–30 seconds while maintaining proper body alignment. The training sessions lasted 30 minutes and were conducted three times per week (Armstrong et al. 2018, 37–44). Table 4 presents the plyometric exercises from two different studies.

TABLE 4. Plyometric exercises from two different studies (Brown et al. 2007, 38–44; Armstrong et al. 2018, 37–44)

Brown et al. 2007:	**Armstrong et al. 2018:**
- 6 weeks - 3 sets - 8 repetitions - 1min recovery between the exercises.	- 5 weeks - series of exercises performed 3 times per week - 30minute each session - exercises increased in difficulty as the study progressed.
1. Depth jumps 2. step-ups 3. box jumps 4. ''froggies''	Week one: - Parallel prances 20sec - Parallel tuck jump 20sec - Scissor jump 20sec - Double leg hop 5reps Week two: - Bounding in place 25sec - Parallel tuck jump front/back 25sec - Parallel tuck jump side/side 25sec - Scissor jump 25sec - Double leg hop 10reps

	Week three: - Bounding for distance 6reps - Parallel pas de chat side/side 30sec - Turned out changement vertical 30sec - Parallel sissonne arabesque front 5reps - Parallel sissonne arabesque side 5reps - Single leg hop hop 5reps Week four: - Bounding for distance 12reps - Parallel pas de chat side/side 30sec - Turned out changement vertical 30sec - Parallel sissonne arabesque front 8reps - Parallel sissonne arabesque side 8reps - Single leg hop hop 8reps Week five: - Jeté développé 6reps - Turned out pas de chat 30sec - Changement turn 20sec - Turned out sissonne arabesque front 5reps - Turned out sissonne arabesque side 5reps - Turned out jeté, coupé, sauté 5reps

For my 2-week trial study, specifically for the plyometric exercises portion (as I have other interventions like neuromuscular training (NMT), resistance training, whole-body vibration (WBV), etc.), I selected the exercises and approach from Brown et al.'s study due to their simplicity and minimalistic nature.

8 WHOLE-BODY VIBRATION

Wyon notes that the use of vibration has garnered significant attention in recent years due to its various effects on the body. In exercise science, numerous studies have explored whole-body vibration (WBV), highlighting its potential to improve physiological attributes such as strength, power, and flexibility. (Wyon, Guinan, Hawkey 2010, 866–870.) Furthermore, Yoon suggests WBV training (WBVT) as a supplement to traditional forms of training for athletes. (Yoon, Kang, Kim, Won, Park, Seo, Ko & Kim 2022, 984–992.)

Wyon explains the hypothesis behind the effectiveness of whole-body vibration (WBV). It is believed that WBV enhances muscular strength and power by increasing neuromuscular facilitation through heightened muscle spindle activation. This activation excites motor neurons, leading to the contraction of homonymous motor units and resulting in a tonic vibration reflex. This tonic contraction can improve the maximum voluntary contraction of muscles, especially when combined with a standard strength training program. These improvements are attributed to motor-unit synchronization and the recruitment of previously inactive motor units. (Wyon et al. 2010, 866–870.)

Yoon explains the operation of whole-body vibration (WBV) machines: WBV is a simple, low-impact exercise method that requires only a vibration platform. The effectiveness of WBV is influenced by several factors, including the type of vibration (oscillating vs. vertical), frequency, amplitude, and acceleration. Additionally, the type of exercise performed during WBV impacts the efficacy of the treatment. Most vibration platforms generate sinusoidal vertical vibrations, with adjustable frequency and amplitude, typically operating within a frequency range of 15-60 Hz and an amplitude range of 1-15 mm (Yoon, et al. 2022, 984–992).

In my research, I will utilize PowerPlate, a device located in the wellness room at Oulu University of Applied Sciences, which transmits sound wave vibrations to the human body.

8.1 Jump height

Wyon explains in his research that several short-term cumulative effect studies have been conducted, using multiple WBV training sessions over periods ranging from 10 days to 6 weeks. These studies have found significant improvements in jump performance after a 10-day intervention involving squats on a vibrating platform. Another study observed enhanced muscular performance following a 3-week intervention. (Wyon et al. 2010, 866–870.)

According to Jones, acute WBV exposure has been shown to enhance vertical jump, acceleration speed, and muscle activity. Results have included improvements in countermovement jump (CMJ), squat jump, knee extensor power, flexibility, and knee extensor strength (Jones 2014, 2461–2469). Additionally, whole-body vibration (WBV) training enhances muscle strength and balance (Yoon et al. 2022, 984–992).

The data reported in the study by Wyon et al. (2010) suggest that WBV training positively impacts vertical jump height due to several neuromuscular adaptations. These include the excitation of the primary endings of muscle spindles, which stimulate increased discharge of alpha motor neurons, and the activation of Golgi tendon organs, which reduce inhibition of muscle action. Additionally, the similarity of biological mechanisms in vibration training and the recruitment of high-threshold motor units contribute to these benefits. (Wyon, et al. 2010, 866–870.)

Wyon et al. (2010) suggest that limited exposure to WBV (2 x 5 minutes per week) is sufficient to stimulate adaptation in the studied population. This may be because, although dancers perform a significant amount of jumping as part of their training, few engage in supplemental fitness training that could lead to physiological adaptation. (Wyon, et al. 2010, 866–870.)

8.2 Muscle groups

In Bellver's trial, the WBV protocol consisted of performing four sets of 45 seconds each, with a 1-minute recovery between sets. While standing on the platform, subjects performed a maximal voluntary isometric contraction of the knee extensors twice, with the knee joint angle at 90° and a frequency of 35-40 Hz. The WBV intervention was conducted only twice a week, resulting in a total training time of just 8 minutes per week (Bellver, Drobnic, Jovell, Ferrer-Roca, Abalos, Del Rio & Trilla 2021, 858–867).

Yoon explains that the squat exercise is particularly effective on Whole Body Vibration (WBV) because it engages multiple muscle groups simultaneously. The vibrations enhance the effectiveness of static squat exercises by increasing muscle activation through the tonic vibration reflex and eccentric contractions. When performing a static squat on a vibration machine, various muscles are engaged due to the nature of the exercise and the impact of the vibrations. The activation of muscles such as the quadriceps, medial gastrocnemius (mGCM), rectus femoris (RF), biceps femoris (BF), tibialis anterior (TA), iliocostalis, and rectus abdominis helps improve muscle strength, power, and endurance. (Yoon, et al. 2022, 984–992.)

- **Quadriceps**: The quadriceps are the primary muscles used in squats. They are responsible for extending the knee and are heavily engaged during the squat position. The vibrations cause small additional stretches in the already contracted quadriceps, leading to eccentric contractions. This helps in enhancing muscle activation and strength.
- **Medial Gastrocnemius (mGCM)**: This muscle, located in the calf, is associated with the Achilles tendon. During the isometric phase of the squat, the mGCM is significantly affected by the vibrations. The tonic vibration reflex activates the mGCM, which helps in improving muscle power and endurance.
- **Rectus Femoris (RF) and Biceps Femoris (BF)**: These muscles are part of the quadriceps and hamstrings, respectively. Knee flexion during the squat reduces the transmission of vibrations to these muscles, but they are still involved in maintaining the squat position and contributing to overall muscle activation.
- **Tibialis Anterior (TA)**: Although the TA is less affected by vibrations compared to the mGCM, it still plays a role in stabilizing the lower leg during

the squat. The reciprocal inhibition caused by the activation of the mGCM can partially cancel out the activation of the TA.

- **Iliocostalis and Rectus Abdominis:** These muscle contribute to core stability during the squat. Core muscles help maintain proper posture and balance during the exercise. (Yoon, et al. 2022, 984–992.)

8.3 Conducting the study

Through several studies on WBV, I have identified multiple exercises that improve jump height, activate muscles, and increase power. Most of these exercises were used in the trial study by Jones, and I will incorporate them into my trial exercise sets as well. (Jones, 2014, 2461–2469.)

Unlike the trials that included professional guidance from scientists and physiotherapists, where the research staff evaluated and provided feedback on the appropriateness of exercises (such as squat position and suitable intervals between repetitions), I will personally assess the appropriateness of each exercise in my study.

This self-assessment approach is a limitation, as it places full responsibility on me and does not guarantee optimal results that could have been achieved with professional assistance.

Yoon et al. state that whole-body vibration training (WBVT) results in a higher muscle load compared to conventional exercise, which can lead to muscle soreness and potentially hinder ongoing training. (Yoon et al., 2022, pp. 984–992). Therefore, I will prioritize recovery, ensure proper alignment, and perform only those exercises from the trials that I am familiar with. The exercise list from the Jones study is detailed in Table 5.

TABLE 5. Progressive overload vibration training exercises performed on the WBV (Jones 2014, 2461–2469)

- D= dynamic hold.
- SH= static hold.

- Low/High= WBV amplitude. - 30/40= WBV frequency - sets 2-4 for 30s.
- Parallel squat (D; low; 30, sets 4x30s) - Parallel squat (D; high; 40; 4x30s) - Squat hold 90° (SH; High; 40; 4x30s) - Split squat (D; high; 40; 2x30s each leg) - Split squat hold 90° (SH; high; 40; 2x30s each leg) - Triceps dip 90° (SH; low; 30; 4x30s) - Front plank (elbows 90°) (SH; low; 30; 4x30s) - Push-up (D; low; 30; 4x30s) - Modified push-up (D; low; 30; 4x30s)

9 JUMP ROPE

While researching the benefits of jumping rope, I have found studies indicating that it is a highly effective exercise for improving jump height, strengthening key muscle groups, and enhancing overall athletic performance. Its advantages extend beyond physical strength, promoting better coordination, agility, and injury prevention, while being a short-term, low-intensity, and highly efficient exercise method.

Research shows that jumping rope is a valuable option for lower limb muscle strength training. It is easy to implement and enriches the strength of muscles such as the glutes, thighs, and quadriceps. Even a small training intensity can stimulate muscle growth and improve lower limb muscle strength adaptations. Studies have confirmed that double rocking jump rope training has a better effect on lower limb muscle strength in sports like rugby, soccer, track and field, tennis, badminton, handball, and other events. (Li, Li 2024, 1–18.)

While there is extensive research on the benefits of jump rope training in various sports, I have not found any research on the effect of rope skipping training in dance. However, the overall benefits of jump rope training suggest it could be a valuable addition to dance training programs as well.

Jump rope training is a full-body exercise that involves both the upper and lower limbs working together against the body's own weight (Li et al. 2024, 1–18). JR requires the body to maintain balance and generate propulsion through coordinated movements of the muscles in both the upper and lower body during continuous activity. It is an effective method for enhancing body coordination by integrating the nervous system and sensory system to a high degree. (Shi, Xuan, Deng, Zhang, Chen, Xu & Lin 2023, 1–10.)

I gathered numerous benefits of jumping rope from different studies and compiled them into Table 6.

TABLE 6. Benefits of jumping rope training (Li et al. 2024, 1–18; Shi et al. 2023, 1–10; Trecroci et al. 2015, 792–798; Garcia-Pinillos, Lago-Fuentes, Latorre-Roman, Pantoja-Vallejo & Ramirez-Campillo 2020, 927–933*).*

(Li et al. 2024, 1–18)
- Improves jump height - Strengthens key muscle groups - Enhances overall athletic performance - Promotes better coordination - Increases agility - Aids in injury prevention - Promotes muscle hypertrophy - Enhances neuromuscular adaptations - Increases muscle fiber size - Strengthens connective tissues - Improves bone density - Promotes weight loss and calorie burning - Reduces insulin sensitivity - Enhances overall strength and cardiovascular fitness - Improves coordination between eyes, feet, and hands - Promotes asymmetry in movements - Promotes balanced muscle strength
(Shi et al.2023, 1–10)
- Engages both upper and lower body - Improves dynamic balance and propulsion - Enhances neuromuscular regulation and control - Develops lower limb muscle fitness - Strengthens the waist, abdomen, and back - Improves the stability of the hip and knee joints - Improves the fast super-isometric contraction ability of the ankle joint

(Trecroci et al. 2015, 792–798)
- Positively impacts heart rate and perceived exertion - Improves cardiovascular and respiratory health - Provides plyometric benefits, reducing contact time and improving jump height - Enhances agility and pre-planned change of direction speed
(Garcia-Pinillos et al. 2020, 927–933)
- Improves power and arch stiffness - Improves jumping ability

9.1 JR for injury prevention

Shi et al. states that incorporating jumping rope into regular training routine can significantly lower the risk of injuries. By strengthening key muscles used in dynamic movements, such as the glutes, thighs, and quadriceps, athletes can achieve better stability and control. This enhanced stability reduces the chances of injuries during high-impact activities and sports (Shi et al. 2023, 1–10).

Additionally, jump rope training boosts the strength and resilience of muscles and connective tissues, which helps prevent strains, sprains, and other lower limb injuries (Li et al. 2024, 1–18). The improved balance and coordination from jump rope training also contribute to preventing falls and related injuries (Shi et al. 2023, 1–10). These benefits collectively enhance lower limbs, further aiding in injury prevention.

9.2 JR improves jump height

Armstrong states that jumping rope is a form of plyometric training, which involves explosive movements that enhance power and speed. Since plyometric exercises have been proven to increase vertical jump height and, to some extent, horizontal jump distance, jumping rope can be an important and easy-to-incorporate workout method to address high jumps (Armstrong et al. 2018, 37–44).

Jump rope tasks with an increased rotation frequency (like in the double-under exercise) provide similar effects of plyometric rebounds, such as reducing contact time and improving jump height. Additionally, it can improve pre-planned agility (i.e., change of direction speed) outcomes (Trecroci et al. 2015, 792–798).

The repetitive, high-intensity nature of jumping rope promotes a highly effective neuromuscular stimulus, leading to significant improvements in jump performance (Garcia-Pinillos et al. 2020, 927–933). One key aspect of jumping rope that contributes to increased jump height is the stretch-contraction cycle. This cycle involves rapid stretching and contracting of muscles, enhancing their ability to generate force. Double rocking jump rope training emphasizes bilateral development in the lower limbs, addressing asymmetry in movements and promoting balanced muscle strength (Li, et al. 2024, 1–18).

Jumping rope (JR) primarily involves the foot muscles and joints due to the quick rebounds (Garcia-Pinillos et al. 2020, 927–933). However, jumping rope engages a wide range of muscle groups, making it an excellent workout for improving jump height. The primary muscles and joints involved in JR include:

- **Glutes**: Generate power for jumps and maintain stability.
- **Thighs**: Engage quadriceps and hamstrings for powerful jumps and quick lateral movements.
- **Quadriceps**: Strengthen lower body and enhance stability. (Li et al. 2024, 1–18.)
- **Calves:** Essential for quick rebounds and explosive movements, involved in jumping rope. They help improve power and arch stiffness.
- **Foot Muscles and Joints**: Improving power, arch stiffness, strength and stability for balance and control (Garcia-Pinillos et al. 2020, 927–933).
- **Hip and Knee joints**: improves and provides stability during the jumps.
- **Ankle joint**: Fast super-isometric contraction ability for explosive movements (Shi et al. 2023, 1–10).

9.3 JR intervention exercises

Research suggests incorporating JR which is high impact and high-frequency activity training between the preparatory activity and technical training of each session (Bellver et al. 2021, 858–867; Shi et al. 2023, 1–10). Trecroci found that performing jumping rope during warm-ups provided greater improvements in subsequent horizontal jumping tasks compared to a warm-up protocol with traditional jumps (Trecroci et al. 2015, 792–798). Therefore, I consider jumping rope not only an effective tool for improving jump height but also a great warm-up intervention tool.

Garcia-Pinillos states that for improving power, arch stiffness, and jumping ability, training with jumping rope instead of 5 minutes of regular warm-up activities has been effective in enhancing performance (Garcia-Pinillos et al. 2020, 927–933).

Here I provide the JR exercise list used in the research studies:

1. Forward double-legged alternating jump rope
2. Reverse double-legged alternating jump rope
3. Double-legged alternating cross jump rope
4. Squatting alternating single-legged jump rope
5. Jumping in own pace
6. Double rocking jump rope (Shi, et al. 2023, 1–10; Li, et al. 2024, 1–18; Garcia-Pinillos, et al. 2020, 927–933; Trecroci, et al. 2015, 792–798).

In my study, a jump rope (JR) intervention will last 8 minutes. I will jump rope at a freely chosen jump frequency, alternating between different jumping exercises that I found in research studies. Given my good stamina, only short breaks will be taken between exercises, if necessary.

JR intervention will be included during the warm-up once per week. This decision is based on my personal experience of using JR interventions for warm-ups before badminton and padel games, which I engage in multiple times per week. Therefore, in my trials, I will focus more on the interventions that I don’t engage in weekly.

10 STRETCHING AFFECTS JUMP HEIGHT

Since dance movements, or high jumps like grand battement, require wide joint movements, and movements like arabesque and developpe require flexibility and strength, incorporating certain stretches into warm-ups is almost unavoidable. While researching the topic of high jumps for dancers, I came across information that certain types of stretching during warm-ups can negatively affect jump height.

Morrin states that including stretching in the warm-up procedure before participating in physical activities, such as dance, is purported to enhance performance and prevent injuries. But different types of stretching used by dancers should be task specific. (Morrin & Redding 2013, 34–40.)

Therefore, it became crucial to educate myself to research and find the most effective muscle stretching modality to incorporate into warm-ups for optimal jump performance, enhance physical skills, and improve aesthetic self-expression.

10.1 Stretching during warm-up

Jumps largely depend on the ability of the athlete to express explosive strength. According to Kisner, explosive strength is commonly impaired by stretching alone. Stretching during the warm-up can potentially decrease explosiveness and reduce performance capabilities. (Kisner, Ramsey, O’Bryant, Ayres, Sands & Stone 2008, 133–140.) Therefore, enhancing or preserving explosiveness after a warm-up that includes stretching would be advantageous for dancers during subsequent performances.

Morrin writes that static stretching (SS) reduces musculotendinous unit (MTU) stiffness, negatively altering the length-tension and force-velocity relationships, and lowering the rate of force development. SS also reduces neural drive, which may inhibit optimal muscle activation. Consequently, engaging in excessive static stretching prior to class is not beneficial. (Morrin et al. 2013, 34–40.)

In contrast to static stretching (SS), Morrin states that the acute effects of dynamic stretching (DS) prior to performance have been shown to enhance many aspects of sports performance, such as lower leg power, vertical jump (VJ) performance, agility, and strength. Therefore, using these findings, Morrin promotes the use of a dynamic stretch routine before engaging in jump performance. (Morrin et al. 2013, 34–40.)

Some of the benefits of DS:

1. **Hight velocity kicks** (Grand Battement)
    a. **Benefits:** DS increases the amplitude of the grand battement at the thigh, leading to larger movements and better aesthetic scores. It also makes the movement faster, with shorter execution times and higher ankle speeds.
    b. **Reasons:** DS induces larger muscular forces, causing greater accelerations and maximal speeds.
2. **Vertical Jumps** (VJ)
    a. **Benefits:** DS enhances vertical jump performance.
    b. **Reason:** DS prepares the muscles for explosive movements, improving power output and jump height. (Dierick, Buisseret, Filiputti & Roussel 2021, 403–422.)

In Kisner's study, which reviewed several studies on flexibility and stretching, I found that the most effective warm-up stretching method was acute local vibrations (V-A), with positive impact on jump height (Kisner, et al. 2008, 133–140). However, due to the lack of necessary equipment at my university, I decided not to include it in my thesis despite its superiority. Sometimes practical constraints can influence the scope of our work, even when certain methods show superior results.

10.2 Combination stretching provides optimum performance of VJ

A study by Morrin compared different stretching methods and their effects on jumping height, concluding that combination stretching (static and dynamic) showed significantly enhanced balance and vertical jump height scores and significantly improved pre-stretch and post-stretch ROM (range of motion) values. Target muscle groups in the research, for better splits and jumps were: quadriceps, hamstring, gastrocnemius and gluteus maximus. (Morrin et al. 2013, 34–40.)

1. **Dynamic Stretch** (DS) Protocol:
    a. Tended toward a negative effect on hamstring ROM.
    b. Had a positive effect on VJ (vertical jump) height compared to SS (static stretch) and NS (no stretch).
    c. Had no significant effect on balance.

2. **Static Stretch** (SS) Protocol:
    a. Had a positive effect on hamstring ROM.
    b. Did not alter VJ (vertical jump) performance in comparison with the NS condition.
    c. Did not alter balance in comparison with the NS condition.

3. **No Stretch** (NS) Condition:
    a. Served as a baseline for comparison with DS and SS protocols. (Morrin et al. 2013, 34–40.)

Morrin states that a combination of static and dynamic stretching appears to be the most beneficial approach for dancers looking to improve their jump height, aesthetics, and overall performance. By combining these methods, the harmful effects of static stretching (SS) can be reduced, leading to better performance outcomes. (Morrin et al. 2013, 34–40.)

The results from Morrin's combined protocol therefore indicate that a cardiovascular (CV) warm-up, followed by 30 seconds static stretches, followed by 30 seconds dynamic stretches, provides the optimum performance of vertical jump (VJ), balance, and hamstring range of motion (ROM). (Morrin, et al. 2013, 34–40.)

11 TRIAL

I created a two-week trial, using several different studies and their materials for workouts, and combined them into three different sessions per week. For time efficiency and to achieve short trial sessions, nearly every intervention was performed once per week, with minimized sets.

For example, the JR intervention is highly used as a warm-up by me before the padel and badminton games that I attend a couple of times per week; therefore, I only included the JR intervention once per week in this trial. However, after familiarizing myself with the JR studies and the exercises used in them, I began to apply the JR intervention in this specific way also before the padel and badminton games.

Some of the exercises used in this trial, particularly from resistance training and plyometric training, are also part of my weekly gym class workouts. Therefore, I concluded that maintaining my current schedule while adding short interventions would be the best way to enhance my strength and conditioning. Consequently, the repetitions or sets per intervention were minimized compared to the original studies. By adapting the interventions to fit my schedule while maintaining their effectiveness, I ensured that the interventions remained efficient and sustainable in the long term.

1. **Combining Intervention Methods**: Since the HFD and WBV interventions require specific equipment, such as a barbell for HFD and a vibration machine for WBV, I decided to combine these interventions. Conducting the study in the Oulu University of Applied Sciences training/wellness class allowed access to both the WBV machine and barbells, facilitating the integration of these methods.

2. **Conducting Interventions at the University:** Because the majority of interventions required specific equipment, such as barbells, jumping box and a vibration machine for WBV, all trials were performed in the wellness room after school or work and on weekends. This added limitations, as it

restricted the ability to perform some interventions more frequently in other places, such as after hobbies or during school hours when the wellness room was booked.

The full two-week trial plan is outlined in Table 7.

TABLE 7. Nino's two-week trial plan.

	Session 1	Session 2	Session 3
Week 1	- NMT - JR - *(Ballet class)* - F-Vimb - WBV	- NMT - *(Ballet class)* - Plyometric training (Brown et al.)	- *(Pilates Reformer class)* - Resistance training (Dowse et al.) - WBV
Week 2	- NMT - JR - F-Vimb - WBV	- NMT - *(Ballet class)* - Plyometric training (Brown et al.)	- *(Pilates Reformer class)* - Resistance training (Dowse et al.) - WBV

11.1 Week one

I did not have a pre-trial week to familiarize myself with every exercise included in the trial. Therefore, during the first week, some interventions were performed slowly to allow time for familiarization. However, many exercises were already familiar to me from resistance training, plyometric training, and neuromuscular training (NMT), so I was able to maintain a good pace.

The WBV and jump rope interventions were very familiar to me even before the trial, making it easy to follow the trial. Overall, the intensity of the trials was not demanding, and I did not experience fatigue, making the interventions manage-able and easy to perform.

11.1.1 Session one (1h 45min)

I decided to use NMT and JR intervention as a warm-up before my ballet class. After the ballet, I conducted the F-Vimb and the WBV interventions. The workout lasted approximately 1 hour and 45 minutes, not including the ballet class.

During the NMT intervention there were no breaks, or only short breaks between the exercises, that were performed at my own pace. The exercise load was comfortable and easy to perform. During the SL landings, I noticed a difference in the force and distance of the jumps between my legs. The balance aspect of the hip airplane exercise was particularly challenging, and once again, I noticed the difference in strength and control between my right and left legs. Walking lunges and side lunges, combined with forward leg swings and cross-body leg swings, were very effective in increasing the moments at the hip. That sensation lasted through the whole workout and later was present even during the ballet class. Overall, the warm-up was not demanding, and I did not experience fatigue. I feel that my performance during the rest of the workout (and the ballet class) was not negatively affected by the warm-up. Instead, I felt more confident and had better control of my movements during the exercises.

Following the NMT intervention, I proceeded with the JR intervention. After completing the JR intervention, I took a break to attend my ballet class. During the class, I noticed positive effects from both interventions: the NMT intervention improved my hip mobility and had a relaxing effect, while the JR intervention enhanced agility and footwork (light and quick foot movements).

Following the ballet class, the F-Vimb intervention was performed. Some exercises from the F-Vimb intervention were familiar from the gym classes that I attend weekly, like back squats, deadlift and clean pull and they were performed with confidence. This made the workout easy, and my body was not challenged much. Other exercises were done slowly. Rest between exercises was 20 seconds, and between sets, it was 1-2 minutes.

After the F-Vimb intervention, I performed the WBV intervention, which included exercises from Jones's study (Jones 2014, 2461–2469). The WBV at the end of the workout had a relaxing effect on my body, leaving me comfortable and not exhausted. The upper body exercises on WBV were not only easy to execute but also very relaxing and soothing. Immediately after the workout, I noticed improved contact with the floor through my feet, as if my entire foot was performing better and balancing my whole body. This could be a sign that my workout effectively engaged the muscles in my feet and legs, enhancing my overall stability. This sensation lasted into the second day as well.

In Table 8, I provide a list of exercises for each intervention.

TABLE 8. Week one. Session one.

1.	**NMT.** Exercises for hip dominant neuromuscular training (Kolokythas et al. 2022, 181–190; Sudds et al. 2023, 139–152). One set. 30min. Exercises performed in order:
	- Plank on elbow – raise the leg (15-20sec) - Plank on hands - raise the leg (15-20sec) - Side plank – on knee (15-20sec) - Squats to releve (10x) - Walking lunges (20x) - Side lunges (20x) - SL – balance - hip rotation (internal 10x and external 10x rotations) - SL – balance - upper body rotation (10x) - Cross-country skiing (20x) - Hip airplane (7x per side) - Forward landings (10x) - Side landings (10x) - SL – forward landings (10x) - SL – lateral landings (5x R; 5x L) - Bear walk – static 3 point contact (20x) - Crab walk – static 3 point contact (20x) - Leg swings forward (10x) - leg swings cross-body (10x)
2.	**JR.** (Garcia-Pinillos et al. 2020, 927–933.) 2 set. Total 8 min. Exercises performed in order:
	- Jumping in own pace

	- Forward double-legged jump rope - Reverse double-legged jump rope - Forward double-legged alternating jump rope - Double-legged alternating cross jump rope - Couple times: double rocking jump rope (this movement is hard, learning to execute it)
3.	**F-Vimb. HFD.** (Escobar Alvarez et al. 2019, 788–794; Jimenez-Reyes et al. 2017, 677.) 3 sets / 6repetitions each exercise. Total 25-30min. Exercise performed in order:
	- Squat jumps - Single-leg CMJs - Back squats - CMJs - Single leg SJ (squat jumps) - Deadlift - Clean Pull
4.	**WBV**. (Jones 2014, 2461–2469.) 4 set, rest between exercises 30-60sec. Total 30min. Exercise performed in order:
	- Squat hold 90° (SH; low; 30sec) - Front plank (elbows 90°) (SH; low; 30sec) - Push-up (bended knees) (D; low; 30sec) - Triceps dip 90° (SH; low; 30sec) - Parallel squat (D; low; 30sec)

11.1.2 Session two (50min)

During the second session, the NMT intervention was already much more familiar and was performed faster and with confidence, before the ballet class. I added two more exercises from the research data and was able to maintain a similar duration of 30 minutes, like the first session.

After the NMT intervention, I took a break for my ballet class. The NMT warm-up positively impacted my dancing during the ballet class. I felt whole-body activation and a hip-dominant approach while dancing. After the ballet class I performed plyometric intervention. Table 9 presents the exercises for each intervention.

TABLE 9. Week one. Session two.

1.	**NMT.** Exercises for hip dominant neuromuscular training (Kolokythas et al. 2022, 181–190; Sudds et al. 2023, 139–152). One set. 30min. Exercises performed in order:
	- Plank on elbow – raise the leg (15-20sec) - Plank on hands - raise the leg (15-20sec) - Side plank – on knee (15-20sec) - SL bride and hold (10x each leg) - Hamstring raises (10x each leg) - Squats to releve (10x) - Walking lunges (20x) - Side lunges (20x) - SL – balance - hip rotation (internal 10x and external 10x rotations) - SL – balance - upper body rotation (10x) - Cross-country skiing (20x) - Hip airplane (7x per side) - Forward landings (10x) - Side landings (10x) - SL – forward landings (10x) - SL – lateral landings (5x R; 5x L) - Bear walk – static 3 point contact (20x) - Crab walk – static 3 point contact (20x) - Leg swings forward (10x) - leg swings cross-body (10x)
2.	**Plyometric intervention.** (Brown et al. 2007, 38–44.) The exercises consisted of 8 repetitions and 3 sets. The intervention lasted approximately 20 minutes, and the exercises were performed at my own pace.
	- Depth jumps - Step ups - Box jumps - ''Froggies''

11.1.3 Session three (40min)

For my third session, I started with a Pilates reformer workout that served as a warm-up. After the Pilates class, I performed resistance training. Following the resistance training, I carried out the WBV intervention. Due to intense dance classes and other activities in the following days, I opted to perform only 2 sets of the WBV intervention instead of the more demanding 4 sets. Table 10 contains a list of exercises for each intervention.

TABLE 10. Week one. Session three.

Resistance training. (Dowse et al. 2020, 3446–3453.) My intervention had only 1 set and lasted approximately 25 minutes. The exercise performed in order:
- SLRDL (16x each leg, 6kg dumbbell) - Split squat (16x each leg, 4kg dumbbell in each hand) - Bent-over row (16x, 4kg dumbbell in each hand) - Push up (16x, on knees) - Squat walk with therapy band (lateral16 steps on each side) - Plank complex (8x) - DB twist (16x, 4kg dumbbell) - Deadlift (16x, 10kg dumbbell) - Hip thrusts (16x, 10kg dumbbell) - Lunge jump (32x)
WBV. (Jones 2014, 2461–2469.) 4 set, rest between exercises 30-60sec. Total 15min. Exercise performed in order:
- Parallel squat (D; low; 30sec) - Squat hold 90° (SH; low; 30sec) - Front plank (elbows 90°) (SH; low; 30sec) - Push-up (bended knees) (D; low; 30sec) - Triceps dip 90° (SH; low; 30sec)

11.2 Week two

During the second week, the exercises became more familiar and the interventions easier to perform, creating a sense of routine. Knowing that the schedule remained the same made preparation and execution stress-free and more effective.

The improvements noted in the previous week were also evident during the second week. Training began to pay off, both in my own dance practice and in my teaching. I started noticing the results, such as improved whole body control, which led to better aesthetics, balance, power, and enhanced hip involvement during dance step executions. The rapid improvements I experienced can be attributed to neuromuscular changes, which enhanced neuromuscular coordination, leading to better control and efficiency in movements.

11.2.1 Session one (1h 5min)

During the second week, session one included interventions of NMT, JR, F-Vimb, and WBV, with a total duration of 1 hour and 5 minutes. The session began with the NMT intervention, which lasted 20 minutes and served as a neuromuscular warm-up for the JR, F-Vimb, and WBV interventions. After the NMT intervention, I performed the JR intervention, which lasted 8 minutes. The NMT and JR interventions were quite manageable, lasting a combined 28 minutes, and left me feeling energetic and alert. Following the JR intervention, I performed the F-Vimb intervention, which lasted 20 minutes. Finally, I completed the session with the WBV intervention, duration 15 minutes. Refer to Table 11 for the list of exercises for each intervention.

TABLE 11. *Week two. Session one.*

1.	**NMT.** Exercises for hip dominant neuromuscular training (Kolokythas et al. 2022, 181–190; Sudds et al. 2023, 139–152). One set. 20min. Exercises performed in order:

	- Plank on elbow – raise the leg (15-20sec) - Plank on hands - raise the leg (15-20sec) - Side plank – on knee (15-20sec) - SL bride and hold (10x each leg) - Hamstring raises (10x each leg) - Squats to releve (10x) - Walking lunges (20x) - Side lunges (20x) - SL – balance - hip rotation (internal 10x and external 10x rotations) - SL – balance - upper body rotation (10x) - Cross-country skiing (20x) - Hip airplane (7x per side) - Forward landings (10x) - Side landings (10x) - SL – forward landings (10x) - SL – lateral landings (5x R; 5x L) - Bear walk – static 3 point contact (20x) - Crab walk – static 3 point contact (20x) - Leg swings forward (10x) - leg swings cross-body (10x)
2.	**JR.** (Garcia-Pinillos et al. 2020, 927–933.) 2 set. Each exercise performed 30-45sec. With breaks 15sec or no breaks between the exercises. Total 8min. Exercises performed in order:
	- Jumping in own pace - Forward double-legged jump rope - Reverse double-legged jump rope - Forward double-legged alternating jump rope - Double-legged alternating cross jump rope - Couple times: double rocking jump rope (this movement is hard, learning to execute it)
3.	**F-Vimb. HFD.** (Escobar Alvarez et al. 2019, 788–794; Jimenez-Reyes et al. 2017, 677.) 3 sets / 6repetitions each exercise. Total 20minutes. Exercise performed in order:
	- Squat jumps - Single-leg CMJs - Back squats

	- CMJs - Single leg SJ (squat jumps) - Deadlift - Clean Pull
4.	**WBV**. (Jones 2014, 2461–2469.) 4 set, rest between exercises 30-60sec. Total 15min. Exercise performed in order:
	- Parallel squat (D; low; 30sec) - Squat hold 90° (SH; low; 30sec) - Front plank (elbows 90°) (SH; low; 30sec) - Push-up (D; low; 30sec) - Triceps dip 90° (SH; low; 30sec)

11.2.2 Session two (40min)

Session two was structured around my ballet class. Starting with a 20minute neuromuscular warmup before my ballet class prepared my body for the movements and techniques required. After the ballet class, I performed a plyometric intervention. Table 12 contains a list of exercises for each intervention.

TABLE 12. Week two. Session two.

3.	**NMT.** Exercises for hip dominant neuromuscular training (Kolokythas et al. 2022, 181–190; Sudds et al. 2023, 139–152). One set. 20min. Exercises performed in order:
	- Plank on elbow – raise the leg (15-20sec) - Plank on hands - raise the leg (15-20sec) - Side plank – on knee (15-20sec) - SL bride and hold (10x each leg) - Hamstring raises (10x each leg) - Squats to releve (10x) - Walking lunges (20x) - Side lunges (20x) - SL – balance - hip rotation (internal 10x and external 10x rotations)

	- SL – balance - upper body rotation (10x) - Cross-country skiing (20x) - Hip airplane (7x per side) - Forward landings (10x) - Side landings (10x) - SL – forward landings (10x) - SL – lateral landings (5x R; 5x L) - Bear walk – static 3 point contact (20x) - Crab walk – static 3 point contact (20x) - Leg swings forward (10x) - leg swings cross-body (10x)
4.	**Plyometric intervention.** (Brown et al. 2007, 38–44.) The exercises consisted of 8 repetitions and 3 sets. The intervention lasted approximately 20 minutes, and the exercises were performed at my own pace.
	- Depth jumps - Step ups - Box jumps - ‘’Froggies’’

11.2.3 Session three (40min)

The third session was performed after the Pilates reformer class and included resistance training and WBV. Starting my trial after the Pilates class was a great way to enhance my strength and stability. After the resistance training intervention, I performed WBV, which had a more relaxing effect on my body, and lasted only 15minutes. The whole intervention (resistance training and WBV) lasted approximately 40 minutes. In Table 13, I provide a list of exercises for each intervention.

TABLE 13. Week two. Session three.

Resistance training. (Dowse et al. 2020, 3446–3453.) My intervention had only 1 set and lasted approximately 25 minutes. The exercise performed in order:
- SLRDL (16x each leg, 6kg dumbbell) - Split squat (16x each leg, 4kg dumbbell in each hand) - Bent-over row (16x, 4kg dumbbell in each hand) - Push up (16x, on knees) - Squat walk with therapy band (lateral16 steps on each side) - Plank complex (8x) - DB twist (16x, 4kg dumbbell) - Deadlift (16x, 10kg dumbbell) - Hip thrusts (16x, 10kg dumbbell) - Lunge jump (32x)
WBV. (Jones 2014, 2461–2469.) 4 set, rest between exercises 30-60sec. Total 15min. Exercise performed in order:
- Parallel squat (D; low; 30sec) - Squat hold 90° (SH; low; 30sec) - Front plank (elbows 90°) (SH; low; 30sec) - Push-up (bended knees) (D; low; 30sec) - Triceps dip 90° (SH; low; 30sec)

11.3 Observations on intervention trials

Although a two-week trial might not be sufficient to see significant improvements in jump height, I was still able to observe some changes as a result of these diverse interventions. This might be because of:

a) My regular gym workouts, including weight training and plyometrics, might have influenced the results. Additionally, I've been practicing Pilates reformer for over 1.5 years, which has strengthened my body. The combination of these activities and the trial interventions has led to overall development and neuromuscular changes more significantly than it could have happened without my regular training. Therefore, combining my activities with trial interventions can potentially amplify the benefits and lead to more noticeable improvements, contributing significantly to my overall development and neuromuscular changes.

b) Wyon states, that studies have found significant improvements in jump performance after a 10-day WBV intervention involving squats on a vibrating platform. (Wyon, Guinan & Hawkey 2010, 866–870.) This suggests that even a 2-week trial of WBV could potentially yield noticeable benefits.
c) Neural pruning improves motor efficiency by removing unnecessary neural connections. Improvements in motor performance are more related to the control of motor neurons rather than muscle strength. This suggests that neural adaptations play a significant role in enhancing performance. (Zhang et al. 2021, 636209.)
d) Hebbian plasticity theory explains that repeated and persistent stimulation of postsynaptic neurons by presynaptic neurons strengthens synaptic connections, leading to adaptive changes in response to training. Consistent and repetitive stimulation during resistance training can lead to stronger neural connections and improved motor control. (Zhang et al. 2021, 636209.)

I observed and documented qualitative improvements in my performance. Here are some findings.

Performance improvements:

- **Jumps:** felt more controlled, and easier to perform.
- **Overall movement:** Improvements were noted in balance, strength and coordination of whole-body movements.
- **Developpé and Battement Exercises**: Noticed improvements in the strength and control of my lower limbs and single-leg movements

Alignment:

- **Hip alignment**: improved to the point where the correct position became automatic, eliminating the need for conscious adjustments.
- **Knee-toe alignment:** improved significantly, especially after a recent injury, to the point where the correct position became automatic during the trial.

Improved muscle awareness:

- **Muscle Engagement**: Strengthening specific muscles during this trial led to a clearer sensation of their engagement during movements. This includes the glutes, rectus femoris, calves, tibialis anterior (TA), erector spinae, lower back muscles, deltoids, chest muscles, triceps, biceps, and core muscles.
- **Joint Strength**: These muscles not only improved the overall execution of dance movements and controlled jumps but also strengthened the hip, knee, and ankle joints.
- **Inner Thigh Muscles**: The biggest discovery was the strengthening of my inner thigh muscles. Through intervention, I developed a clear sensation of these muscles during movements, which I previously lacked.

Turnout and mobility:

- **Hip Turnout**: Improved from the hip area, resulting in more mobile hips and higher leg lifts.
- **Class Experience**: During the entire ballet classes, my hips felt relaxed, more open, and more engaged in the exercises, making them easier and more pleasant to perform than ever before.
- **Floor Contact**: I experienced a better sensation of contact with the floor through the soles of my feet, which improved my balance during barre, center, and diagonal exercises.
- **Port de Bras**: Sensed better control and overall feeling of the hip muscles. A strong sense of connection between the hip muscles and the lower limbs and upper body helped me move my arms, head, and legs simultaneously in different directions without losing balance. My conditioning led to a better sense of connection between different muscle groups, improving my ability to perform complex movements more efficiently.
- **Pirouettes**: My supporting leg felt sturdier, and I had a strong sense of muscle engagement and connection throughout my body, including the balls of my feet, hip alignment, upper body strength/control, and power in my arms. As a result, I experienced more balanced and controlled pirouettes, with a strong sense of power and the ability to control my turns.

It is important to note that these trials have uniquely combined the benefits of all my various activities. As a result, my body has gained greater expressivity and significantly improved aesthetics. Now, by controlling and intentionally executing exercises, I experience more elegant and coordinated whole-body movements. I believe that because the trial engaged a wide range of muscles and employed various methods to influence them, it quickly enhanced body coordination by integrating the nervous and sensory systems to a high degree, as if tuning the body like a musical instrument for perfect performance.

In Table 14, I have gathered a comprehensive list of the major muscle groups and joints involved in the various exercises and movements performed in my trials.

TABLE 14. Comprehensive list of the major muscle groups and joints involved in the various exercises and movements performed in trials.

Lower body muscles	- Glutes - Thighs *Rectus femoris* *Biceps femoris* - Quadriceps - Calves *Medial gastrocnemius (mGCM)* - Foot muscles - Tibialis anterior (TA)
Core muscles	- Rectus abdominis - Transverse abdominis - Obliques - Iliocostalis
Back muscles	- Erector Spinae - Lower back muscles

Upper body muscles	- Deltoids - Chest muscles *Pectoralis major* *Pectoralis minor*

11.4 Significant insights

Last year, I took a dance course that included a dance sequence derived from the Matt Mattox technique, with a focus on isolating the hips. My progression through the Matt Mattox exercise sequence during the course was slow. While performing the sequence, my body was not only learning dance steps but also working to improve balance and overall stability, particularly in the hips, knees, and ankles. This was especially challenging during single-leg movements. However, relying solely on dance training was problematic because it overlooked the physical demands required for performance. As a result, the likelihood that dance training alone significantly maximized my potential and improved the power and strength needed to execute the sequence was quite low.

Dowse states that skill acquisition during a formal dance class does not sufficiently provide technical, physical, and aesthetic components. Dancers possess fitness levels comparable with sedentary persons of a similar age, present only 77% of the weight-predicted strength norms, and commonly display weakness around the knee joint and muscular imbalances. This further highlights the limitations of relying solely on dance training for overall development. (Dowse et al. 2020, 3446–3453.)

On the other hand, supplementary training closes discrepancies between technical abilities and physical fitness (Dowse et al. 2020, 3446–3453). If we had incorporated task-specific strength training exercises during warm-ups, such as the Single Leg Romanian Deadlift (SLRDL) and Hip Airplanes, which enhance hip stability, whole-body control, and overall performance, I believe we would have been better prepared for the dance sequence. These exercises specifically target the muscles and neural pathways involved in maintaining hip balance and control, which are essential for performing complex dance movements like SL plies, tilts, rond de jambes, and more, and are crucial for performing complex dance techniques like those in the Matt Mattox method.

Neuromuscular adaptations play a crucial role in enhancing performance. Immediate responses to exercises, which may be due to neural pruning and strengthened neural connections rather than muscle strength, can significantly speed up a dancer's development (Zhang et al. 2021, 636209). This means that incorporating targeted exercises can quickly improve coordination, balance, and overall control, allowing dancers to progress more efficiently and effectively in their training.

In the short term, this approach will allow me to focus more on the dance steps and expressivity, as my body will be better equipped to handle the physical demands. In the long term, supplementary training will help the body gain more power, strength, and control, leading to improved performance. This inspired me to create a list, shown in Table 15, highlighting the differences between dancers who engage in supplementary training and those who do not.

TABLE 15. Potential differences between dancers with and without supplementary training.

	Without supplementary training	**With supplementary training**
Skill acquisition	Relies solely on dance training, leading to slower progress	Enhanced by strengthening and preparing the body, leading to faster progress
Progress	Skill acquisition is slow	Faster skill acquisition
Impact	Limited improvements in physical, technical, and aesthetic components. Less fluid and graceful movements	Significant improvements in physical and technical abilities, leading to more fluid and graceful performances
Potential	Dancers do not reach their full potential. Less explosive movements and lower jumps	Provides the possibility to achieve full potential. More explosive movements and higher jumps.

Fitness levels	Comparable to sedentary individuals of similar age. Reduced stamina	Overall fitness and strength are improved. Improved stamina
Injury risks	High level of injury risks. Common weaknesses around the knee joint and muscular imbalances	Reduced injury risks and dance-related aches or pains. Stronger muscles, joints
Physical competence	Essential attributes like coordination, flexibility, strength, and balance are not fully developing	Boosts the development of essential attributes like coordination, flexibility, strength, and balance

12 CONCLUSION

I leveraged existing scientific research to design my training program, aiming to make the most of the existing knowledge and potentially enhance my outcomes. By focusing on optimizing the application of proven methods rather than revalidating them, I saved time and potentially achieved better results more efficiently.

In conclusion, this thesis hypothesizes that integrating various training methods, such as resistance training, force-velocity imbalance (F-Vimb), plyometric training, neuromuscular training (NMT) with a hip-dominant focus, whole-body vibration (WBV), and jump rope exercises, can significantly benefit dancers. These methods aim not only to improve jump height but also to prevent injuries and enhance aesthetics.

Additionally, they are designed to be short and easy to implement, making them practical for dancers seeking to optimize their performance and physical conditioning. By targeting specific goals and tasks, this diverse approach addresses multiple muscle groups and enhances neuromuscular adaptations, leading to a more comprehensive and effective physical conditioning program to improve jump heigh.

12.1 Restating research objectives

The primary objective of this research was to explore the impact of short supplementary training on dancers' performance, with a particular focus on jump height, balance, and overall physical conditioning. The goal was to determine whether integrating specific strength and conditioning exercises could enhance dancers' abilities more effectively than traditional dance training alone.

Using scientific research and data, I developed and conducted an effective and comprehensive training program that targets a wide range of muscles and applies various types of load on the muscles to improve jump height.

In a two-week trial, I observed and documented qualitative improvements in my performance, including enhanced alignment, improved muscle awareness, better turnout and mobility, better control during jumps, increased coordination, flexibility, strength, and balance, improved stamina, and more fluid and graceful movements. Overall, my performance in dance classes improved in every aspect, not just jumps.

12.2 Summarizing key findings

The results suggest that relying solely on dance training may not adequately prepare dancers for the physical demands of performance. The inclusion of task-specific supplementary training can enhance neural connections and coordination, leading to quicker improvements in performance. This approach can help dancers develop high-level performance skills faster and transition into professional dancing more smoothly.

Incorporating supplementary conditioning can significantly enhance dancers' neuromuscular efficiency, muscle strength adaptations, and overall performance. This approach leads to quicker development of technique, better aesthetics and comprehensive development of dancers’ physical abilities.

The findings highlight the importance of a well-rounded training regimen that includes both dance-specific practice and strength and conditioning exercises. By creating a short, task specific and time-efficient, well-rounded training regimen, dancers can significantly improve their overall performance, physical capabilities, coordination and motor efficiency. This makes it a valuable strategy for those seeking to enhance their jump height and overall athletic performance.

Conducting strength and conditioning training with the aim to distribute weight onto the hip joints can help avoid and decrease knee and lower extremities injuries, which are commonly caused by jumping in dance population.

Integrating various training methods such as resistance training, force-velocity imbalance (F-Vimb), plyometric training, neuromuscular training (NMT) with a hip-dominant focus, whole-body vibration (WBV), and jump rope exercises can significantly benefit dancers. Despite the limited trial time, the results highlighted improvements in neuromuscular efficiency and overall performance. Observations showed qualitative enhancements in alignment, muscle awareness, turnout, mobility, coordination, flexibility, strength, balance, stamina, and fluidity of movements.

Achieving high levels of physical fitness and performance necessitates supplementary conditioning that bridges the gap between technical abilities and physical fitness. To achieve and maintain high levels of physical fitness and performance, I recommend engaging in a variety of supplementary training. While it's important to target specific tasks like high jumps with dedicated supplementary training, it's equally important to incorporate a wide range of supplementary exercises that will boost overall body fitness, power, and coordination. This approach will also positively influence and accelerate the effects of the targeted specific supplementary training, such as improving jump height.

Therefore, dance schools should consider integrating structured strength and conditioning programs into their curriculum, potentially in collaboration with physical therapists or certified trainers. This approach can accelerate dancers' development, reduce injuries, enhance aesthetics, maximize potential, and extend dance careers.

Even a short intervention period of just 2 weeks, utilizing a diverse approach, can significantly enhance neuromuscular efficiency across various muscles and improve overall jump performance. Hip-dominant neuromuscular training enhances function, balance, and stability, preparing the body efficiently for jump performances. Resistance training improves lower-body strength and power, which are crucial for jumping. F-Vimb optimizes resistance training to improve ballistic performance quickly. Plyometric training enhances strength, power, and jump height in a short period by training muscles to exert maximum force. WBV improves strength, power, flexibility, and jump performance with limited exposure per week. JR strengthens key muscles, improves stability and control, and enhances joint stability, leading to better jump performance. The benefits of each intervention used in the study are summarized in Table 16.

TABLE 16. Summarizing the benefits of each intervention used in the study.

Hip-Dominant Neuromuscular Training
- Increases moments at the hip while reducing moments at the knee, preparing the body for safe and efficient jump performances. - Enhances function, balance, hopping distance, stability, and upper extremity strength (Long et al. 2021, 404–417).
Resistance Training
- Significantly improves lower-body strength and power, dynamic balance, and dance performance in adolescent dancers (Dowse et al. 2020, 3446–3453).
F-Vimb (Force-Velocity Imbalance)
- Considered valuable for prescribing resistance training to improve ballistic performance, such as jumping and countermovement jump (CMJ), in female ballet dancers (Escobar Alvarez et al. 2019, 788–794).
Plyometric Training
- Enhances strength, power, and jump height (Girard et al. 2015, 233–240). - Proven effective in enhancing athletic performance and may also improve horizontal jump performance (Armstrong et al. 2018, 37–44). - Trains muscles to exert maximum force in short intervals (Dowse et al. 2020, 3446–3453).
Whole-Body Vibration (WBV)
- Improves strength, power, and flexibility (Wyon et al. 2010, 866–870). - Significant improvements in jump performance after interventions involving squats on a vibrating platform (Wyon et al. 2010). - Activates muscles such as quadriceps, medial gastrocnemius, rectus femoris, biceps femoris, tibialis anterior, iliocostalis, and rectus abdominis (Yoon et al. 2022, 984–992). - Suggested as a supplement to traditional training for athletes (Yoon et al. 2022). - Improvements in CMJ, squat jump, knee extensor power, flexibility, and knee extensor strength (Jones 2014, 2461–2469). - Effective with limited exposure (2 x 5 minutes per week) (Bellver et al. 2021, 858–867).
Jumping Rope
- Significantly lowers the risk of injuries (Shi et al. 2023, 1–10).

- Strengthens key muscles used in dynamic movements, such as glutes, thighs, and quadriceps, improving stability and control (Garcia-Pinillos et al. 2020, 927–933).
- Improves hip and knee joint stability (Armstrong et al. 2018, 37–44).
- Bilateral Development: Addresses asymmetry in movements and promotes balanced muscle strength (Li et al. 2024, 1–18).
- Horizontal Jumping: Greater improvements in horizontal jumping tasks compared to traditional warm-up protocols (Trecroci et al. 2015, 792–798).

12.3 Limitations of my study

There are few limitations of my study, including the lack of specialized equipment and expertise, the absence of expert guidance, the short duration of the trial, reliance on self-study and continued supplementary training.

1. Without the proper tools and scientific knowledge, accurately measuring jump height can be challenging.
2. Not having sports scientists to guide can make it difficult to ensure the accuracy of performed exercises.
3. A two-week trial may not be sufficient to observe significant changes in muscle structure and jump height.
4. Exploring and researching a new field independently can be time-consuming and might leave some areas less understood, thus preventing deeper research and intuitive approaches from being fully realized.
5. My ongoing gym workouts, including weight training and plyometrics, might have influenced the results.

12.4 The need for physical interventions and physician involvement

Relying solely on dance training is a significant issue in the dance community. The physical demands of dance are indeed rigorous, and traditional training programs often focus heavily on technique and choreography, sometimes at the expense of strength and conditioning. This can lead to challenges for dancers who may not have the knowledge or resources to manage their physical conditioning independently.

The lack of fitness education and lack of physician's support is problematic not only for beginner dancers but also for advanced dancers who rely solely on dance-specific technique training and do not progress significantly during their school years. Given the brief span of a dance career, it's crucial for dancers to seize every opportunity to maximize their performance potential, whether it's during the school year or in every dance class.

Integrating strength and conditioning into dance training is essential for the holistic development of dancers. By involving fitness professionals in dance schools, dancers and teachers can benefit from personalized and task specific training plans that not only enhance performance but also reduce the risk of injury. Working with fitness professionals will help students understand their unique physique, identify their strengths and weaknesses, and develop methods to improve their limitations. Collaboration between dance instructors and physicians can lead to more holistic training programs that consider both physical and artistic well-being.

Therefore, I recommend that dance education systems consider implementing physical interventions that will support and educate dance population. This approach can significantly contribute to the development of the dance industry, education, and overall well-being of dancers and seize every opportunity to maximize their performance potential. It ensures that dancers are not only technically proficient but also physically prepared to meet the demands of their art form, thereby extending the brief span of a dance career. Balancing traditional dance training with modern strength and conditioning techniques can create a well-rounded approach that benefits everyone involved.

12.5 Suggestions for future research

I recommend that future research focuses on developing tailored programs for dance schools. These programs should specifically aim to use methods that enhance muscle recruitment and neural activation, leading to improved coordination and motor efficiency. This is crucial for precise control over movements, which is essential for both performance and aesthetics.

Research focus areas could include:

- neural activation techniques,
- muscle recruitment strategies,
- coordination and motor efficiency and
- task-specific training.

Additionally, it would be beneficial to organize workshops and seminars, as well as customized training plans on this topic in dance schools to monitor progress and adjust training programs as needed.

Developing tailored programs for dance schools could significantly enhance dancers' skills. Considering the short career span of dancers, it's essential to maximize training efficiency. Quick, effective, and task-specific interventions, along with medical support, could help dancers achieve their peak performance faster and sustain it longer.

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