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Research article

Influence of the sport specific training background on the symmetry of the single legged vertical counter movement jump among female ballet dancers and volleyball players

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A R T I C L E I N F O

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A B S T R A C T

Introduction: Vertical jumps are the key components of performance in the classical ballet and volleyball. Asymmetry of performance between the lower extremities is a potential risk factor for injury.
Purpose: The purpose of this study was to analyse the symmetry of the unilateral vertical countermovement jump (CMJ) in a group of female ballet dancers and in a group of female college volleyball players.
Methods: We tested the CMJ with the dominant and nondominant leg and the bilateral CMJ among 15 female ballet dancers and 15 female volleyball players aged 18–24 years. Ground reaction forces were recorded with the force plate and five variables were analysed - jump height, power, energy, and time to flight and time to maximum force during landing.
Results: 2 × 2 repeated measures of ANOVA indicates that type of sport is influencing some of the single leg CMJ variables (energy used and time to maximal force in landing), there was a significant asymmetry between dominant and non-dominant leg in some of the vertical CMJ variables (CMJ height, energy used and the average power was marginally significant). The interaction between the type of sport and leg dominance however was not significant for all of the analysed CMJ variables indicating no difference in asymmetry between the dominant and non-dominant leg in the two investigated sports. The results expressed in the percentage differences between both legs that is widely used in the scientific literature showed that ballet dancers exhibited more symmetrical CMJ height, power, and energy compared to volleyball players. The average percent difference in CMJ height between the dominant and non-dominant leg was 4.26 (10.60) % and 13.36 (14.72) %, respectively. On average, volleyball players jumped slightly higher at the bilateral CMJ ($p < 0.001$).
Conclusion: Sport-specific training background could explain the observed contralateral deficit differences between two sport groups. The elements of ballet training could be introduced into the volleyball training to overcome observed this contralateral deficit.

1. Introduction

Different types of vertical jumps are an important component of athletic performance [1]. Adequate muscle performance is therefore essential in various sports. Additionally, symmetry between the dominant and non-dominant leg is one of the characteristics closely related to the athletic performance [2, 3, 4], and its imbalance is a significant risk factor for injury during training and competition as well as recreational activities [5]. The degree of symmetry depends on the sport-specific activities and training [2, 4]. There are sports that exhibit high levels of asymmetry, such as soccer [2, 3, 4,6] and those that do not, e.g., swimming, sprints, distance running [3, 4]. Volleyball and classical ballet could be considered as sports activities with less sport-specific asymmetry.

Balett dancers are both athletes and artists since their performance requires high muscular and aerobic performance, coordination, flexibility, as well as the beauty of the movements in the choreography [7]. In addition, ballet is considered as a very demanding and strenuous athletic activity [8], in which vertical jumps are the essential component [9].

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Volleyball requires various vertical and horizontal jumps [10] that are the key components. Jumps are the basic skill for attack, serve and block and require a high level of physical fitness [11], explosive power, coordination for jumps at the right angle and perfect timing [10]. Therefore, volleyball players need optimal muscle strength, flexibility and quick reactions. Besides the height of the jump, landing is also an important part of vertical jump during attacks and blocks. The landing phase requires the dissipation of kinetic energy, as the height of the jumps increases the kinetic energy that must be properly absorbed to avoid damage/injury [12]. For almost all offensive and defensive jumps, volleyball players use jumping with both legs, which gives the athlete a wide and stable base to perform the best possible attack or defence. In contrast, landing on one foot is not stable and the risk of injury upon landing is much higher [5]. On average, 45 jumps were recorded per game, and the highest number of jumps recorded by an individual was 73 [12]. The sport-specific training background and physical performance of jumps are strongly related and optimal combinations of muscle strength and speed to maximize athletic performance is needed. Furthermore, anaerobic and aerobic power plays another crucial part in physical performance of jumps. Popadic et al. [13] have compared the maximum anaerobic performance between different athletes, and volleyball players showed the highest values in anaerobic power.

Several methods have been proposed to assess lower limb strength asymmetry. By far the most common is the isokinetic assessment. It quantifies bilateral force of specific muscle groups such as the knee extensors and flexors. However, it requires very expensive equipment, and assesses open kinetic chain movements and isokinetic muscle action, while the most athletic activities are characterised by closed kinetic chain movements and rapid muscle actions with the stretch-shortening cycle. For these reasons, functional tests such as the single-leg jump test have been developed [6]. With the vertical jump test it is possible to directly measure the force generated by each leg during the vertical CMJ. The results of the study by Impellizzeri and colleagues [6] showed a statistically significant correlation between the vertical jump test and the isokinetic leg extension test. Although the recent review showed agreement between the isokinetic measurement and the CMJ [14], the more functional nature of the CMJ may provide a more comprehensive insight into neuromuscular function through a detailed analysis of the CMJ force-time curve [15].

The characteristics of the jumping movement (stretch-shortening cycle, closed kinetic chain, and relatively high velocity) are similar for most jumps in athletic activities. In addition, the control of the arms removes the influence on the test results, which better reflects the function of the lower extremities [6]. Both the vertical jump test and other closed-chain tests provide a global measure of bilateral strength and asymmetry and may be more functionally relevant to athletic performance [6] and rehabilitation after injury. Therefore, vertical jumps are often used as an index of lower limb function or its explosive power [16]. There are different types of jump tests that require different muscle functions [17]: the vertical squat jump, a vertical countermovement jump, and a cyclic jump. The starting position differs between the vertical squat jump and the vertical countermovement jump. In the former, the starting position is the squat, while the other is the standing position, from which the subject only then squats and jumps upwards. This manoeuvre allows the development of a greater force and consequently a higher jump [18]. The speed of the jump, force, acceleration and torque are the physical quantities involved in any type of vertical jump [16].

Single-leg jumps are more functional than bilateral jumps [2], they are a more reliable indicator of lower limb function [17], which has been reported for rugby players [19], football players [2] and other athletes [17]). The single-legged jump has an advantage over the double-legged jump due to leg asymmetry, possible consequences of previous injuries, and due to its better predictive value for injuries and better feedback for training planning [2]. Additionally, some studies suggest that leg force asymmetry may be a risk factor for musculoskeletal injuries [12,20]. Therefore, its measurement may also be useful to identify athletes at increased risk for lower limb injuries during training and competition [6].

Volleyball players must have a good vertical jump performance with the highest possible jump in the attacking situation [10]. On the other hand, ballet performances place a lot of emphasis on vertical jumps, which should look smooth and elegant at the same time, in addition to jump as high as possible [8]. Therefore, we tested three vertical CMJ (bilateral and single legged with dominant and non-dominant leg) in a group of ballet dancers and a group of volleyball players. In the scientific literature [9, 18, 21, 22, 23] bilateral jumps are still reported, so we decided to measure both the unilateral and bilateral CMJ to allow comparison with previous reports. The aim of the study was to evaluate the symmetry of the unilateral vertical CMJ in a group of female ballet dancers and a group of female volleyball players. We hypothesised that there would be no asymmetry between dominant and non-dominant leg within the group and no difference between the two groups.

2. Materials and methods

2.1. Participants

Thirty female athletes participated in the study. Fifteen were invited from the Stevens Ballet School and 15 from three non professional College Volleyball Clubs. To ensure a homogeneous group, only female players and ballet dancers were studied due to differences in muscular performance characteristics between the genders [8, 9, 16, 24]. The exclusion criteria were injury in the past year, systemic disease, and training volume of less than three times per week. The study was approved by the Medical Ethics Committee of Republic Slovenia (number 0120-291/2018-8.) Participants were between 18 and 24 years old, training ballet or volleyball three to six times per week. Detailed descriptive data for both groups are presented in Table 1.

2.2. Testing protocol

Before the test, participants performed a standardised 5-min warm-up. Participants were asked to step on the 15 cm high bench at a pace of 88 beats per minute. The leading leg was changed after two and a half minutes. The main muscle groups of both legs (quadriceps, hamstrings, and calf muscle) were then stretched, with each stretch held for 10 s. Dominance was determined by the push test [4]. The leg that performed the step was considered the dominant leg.

The order of the vertical CMJ test was as follows: first the vertical CMJ with both legs, then the vertical CMJ with dominant leg, and finally the vertical CMJ with the non-dominant leg. Participants stepped onto the force plate with their legs hip-width apart and arms held at the crista iliaca (Figure 1). For the unilateral jump participants stepped with one leg into the middle of the force plate, the other leg was held between 90 and 60 degrees of knee flexion and arms were held at the crista iliaca. Participants were instructed to stand still on the force plate for 2 s and they have received instruction to jump as high as they can. For familiarisation, participants performed two test jumps for each jump type. There was a 20-second rest between each repetition, and each jump type was followed by a 2-min rest.

As described by McMahon et al. [15], the CMJ can be divided into six phases: the stance phase, the unweighting or countermovement phase, the braking phase, the propulsion phase, the flight phase, and the landing phase. In the countermovement phase, the center of mass is first moved downward until it reaches its lowest point. During the propulsion phase, the ground reaction force is large and corresponds to acceleration. The propulsion phase begins when the concentric contraction follows the eccentric contraction. Changing the velocity from zero in the propulsion phase to a positive value in the take-off phase results in a change in momentum. The change in momentum should be maximized to generate maximum velocity during take-off [16]. The flight phase follows the take-off phase when the jumper is in the air. The landing phase begins

Table 1. Descriptive data for the ballet dancers and volleyball players as mean with standard deviation (SD).

	Ballet mean (SD)	Volleyball mean (SD)	p value
Age (years)	20.3 (1.2)	20.1 (1.1)	0.764
Body height (cm)	166.2 (5.5)	175.0 (5.3)	<0.0016
Body weight (kg)	57.2 (5.5)	68.5 (6.5)	<0.001
BMI (kg/m2)	20.7 (1.6)	22.4 (2.3)	0,03
No. of trainings per week	3.7 (1.0)	4.5 (1.0)	0,03

when the jumper touches the surface and ends with a standing position (Figure 1).

2.3. Instrumentation and data processing

The measurements of the experiment were performed at Biomechanical Laboratory of the Faculty of Health Sciences. A Kistler 9286 AA force plate with associated BioWare software was used. The acquired time series were analysed using StabDat 3.1. software [25]. We analysed five variables: two for counter movement and propulsion, one for the flight phase, and two for the landing phase: (i) time from the beginning of the movement to flight (s); (ii) height of the jump (m); (iii) energy expended (J); (iv) power (W); (v) time to maximum force in the landing phase. Based on the height of the jump in each category, the best jump out of the three measured jumps was used for further analysis [9]. The reliability of the CMJ variables as recorded by force plate was established in previous research and is good to excellent for bilateral [26] as well as for unilateral vertical CMJ [27] and different acquisition and calculation methods [28]. Specifically for the equipment and protocol used in this study, the test-retest reliability of the vertical bilateral and single leg CMJ was assessed. The reliability of single leg CMJ was good to excellent for the height of the jump, energy expended and power ($ICC_{(2,1)}$ 0.895, 0.937and 0.947, respectively) and moderate for the time from the beginning of the movement to flight and time to maximum force in the landing phase ($ICC_{(2,1)}$ 0.752 and 0.730, respectively). The detailed data is part of the laboratory manual [29].

The jump height was calculated from the gravity acceleration (g) and the time (t) in the air (flight time). Height of jump (cm) = $gt^2/8$ [17, 22, 30]. Energy expenditure (J) was calculated E = mgh (m = body mass (kg), g = gravitational acceleration, h = jump height (m)). Power (W) was calculated energy (J)/time (s) (P = E (J)/T1(s)). Since body height has no effect on CMJ height [9, 16, 24, 30], it was not included in the calculation.

2.4. Statistical analysis

The statistical package for social sciences SPSS 27 (Chicago, Illinoy, USA) was used. Data were inspected for normality, and given the normal distribution parametric tests were used. A 2 × 2 repeated measures of variance (2 × 2 ANOVA) was used to assess symmetry between the dominant and non-dominant legs of both groups. The percentage difference between dominant and non-dominant leg was calculated with the formula (dominant—non-dominant)/non-dominant) * 100) [31]. An independent t test was used for comparison of bilateral CMJ and percentage difference between the two groups. G * Power 3.1 [32] was used to calculate the sample size.

3. Results

The results are presented in two levels. First, the results of 2 × 2 ANOVA for comparison between the dominant and non-dominant leg for both groups and analysis of percentage difference, followed by the comparison between the two groups, of the bilateral CMJ between the two.

3.1. Unilateral CMJ of dominant and non-dominant leg

A (2 × 2 volleyball or ballet × dominant or non-dominant leg) repeated measures ANOVA was calculated. For the unilateral CMJ a statistically significant main effect for the **type of sport** was found for two of the observed variables: energy used ($F_1 = 16.657, p < 0.001, \eta^2 = 0.543$) and time to maximal force in landing ($F_1 = 5.485, p < 0.034, \eta^2 = 0.587$), while the main effect for type of sport for CMJ height, average power and time to flight was not significant ($F_1 = 1.893, p < 0.190, \eta^2 = 0.119$; $F_1 = 1.009, p < 0.332, \eta^2 = 0.067$); ($F_1 = 1.300, p < 0.273, \eta^2 = 0.085$)) respectively, which indicates that type of sport is influencing some of the single leg CMJ variables.

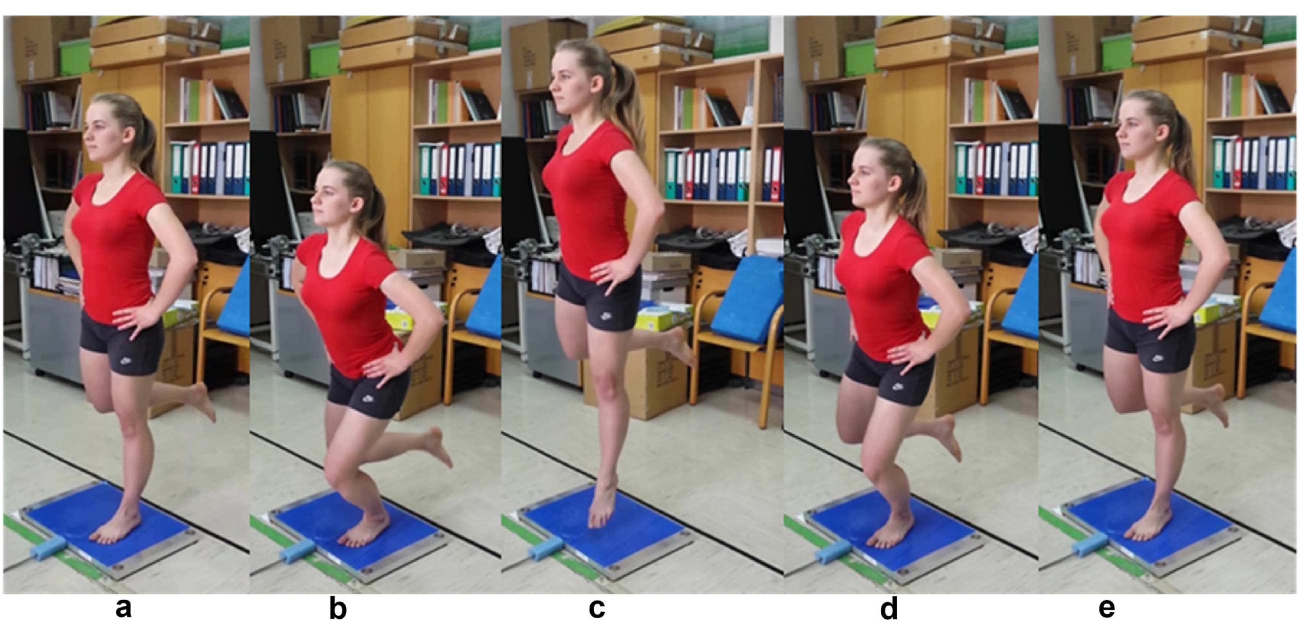

Figure 1. The unilateral vertical counter movement jump, (a) starting phase, (b) counter movement (unweighting, braking and propulsion, (c) flight, (d) landing, (e) final position.

The main effect of **leg dominance** was significant for two of the observed variables: jump height ($F_1 = 14.264, p < 0.002, \eta^2 = 0.505$) and energy used ($F_1 = 16.657, p < 0.001, \eta^2 = 0.543$), the average power was marginally significant ($F_1 = 4.330$, $p < 0.056$, $\eta^2 = 0.236$), while the main effect for leg dominance for time to flight and time to maximal force in landing were not significant ($F_1 = 2.184, p < 0.162, \eta^2 = 0.135; F_1 = 0.006$, $p < 0.939$, $\eta^2 < 0.001$,respectively), which indicates that there was a significant asymmetry in some of vertical CMJ variables.

The **interaction** between the type of sport and leg dominance was not significant for all the analysed CMJ variables: jump height ($F_1 = 3.584, p < 0.079, \eta^2 = 0.204$), energy used ($F_1 = 0.772, p < 0.394, \eta^2 = 0.052$), the average power ($F_1 = 0.297, p < 0.594, \eta^2 = 0.021$), time to flight ($F_1 = 1.214, p < 0.289, \eta^2 = 0.080$) and time to maximal force in landing ($F_1 = 0.335$, $p < 0.575$, $\eta^2 < 0.023$) indicating no difference in asymmetry between the dominant and non-dominant leg in the two investigated sports.

Considering the significant main effect for the leg dominance, we have calculated the percentage difference between dominant and non-dominant leg for each participant and compared it between the two groups. The average percentage differences with their standard deviations for single leg vertical CMJ are shown in Table 2. The percentage difference that indicates the degree of asymmetry between the dominant and non dominant leg, was compared between the two groups and the height of vertical CMJ was nearly significant (p = 0.06).

3.2. The bilateral CMJ of the groups

The comparison between the two groups showed a significantly higher bilateral CMJ of the volleyball players (p = 0.045) and a significantly higher energy expenditure (p < 0.001) as well as time to flight (0.039). The detailed results for all the variables of the three vertical CMJ jumps of both groups are presented in Table 3.

3.3. Sample size calculation

The sample size calculation for future research was calculated for the two variables, with the required power set at 80 percent. When the difference between the dominant and non-dominant leg is chosen as the main variable, the calculated sample size is 52 participants (26 in each group). When CMJ height with the dominant leg is chosen as the main variable, the calculated sample size is 102 participants (51 in each group).

Table 2. The percentage difference between dominant and non-dominant leg and p values for comparison between volleyball and ballet group.

Group Variable	Volleyball players	Ballet dancers	t-test
	Average difference % (SD) Range	Average difference % (SD) Range	P
Time to flight	0.91 (8.77)	19.17 (47.47)	0.154
	−11.26–19.68	−24.03–144.85	
The height	13.36 (14.72)	4.26 (10.6)	0.062
	−5.13–22.79	10.15–21.23	
Energy used	10.39 (21.08)	4.27 (10.90)	0.326
	−45.11–54.37	−10.82–20.17	
Average power	9.66 (23.67)	3.83 (16.16)	0.438
	−38.94–66.75	−25.02–31.17	
Time to maximal force in landing	−0.13 (17.94)	4.36 (24.18)	0.568
	−26.92–37.23	−27.64–66.67	

Table 3. Descriptive data of the unilateral jump with dominant and non-dominant leg and the bilateral jump for both sport groups.

Variable Group	Unilateral CMJ Dominant leg (SD)	Unilateral CMJ Non-dominant leg (SD)	Bilateral CMJ Both legs (SD)
Time to flight (s)	0.97 (0.15)	0.96 (0.13)	1 (0.19)
Volleyball players	0.95 (0.27)	0.84 (0.25)	0.83 (0.24)
Ballet dancers			
The height (m)	0.11 (0.02)	0.10 (0.019)	0.27 (0.04)
Volleyball players	0.10 (0.02)	0.10 (0.01)	0.25 (0.03)
Ballet dancers			
Energy used (J)	72.94 (19.51)	66.65 (14.30)	183.23 (32.96)
Volleyball players	56.43 (12.03)	54.09 (9.87)	138.12 (18.76)
Ballet dancers			
Average power (W)	207.31 (63.37)	192.16 (54.69)	604.16 (150.92)
Volleyball players	189.79 (48.82)	182.33 (39.64)	554.05 (125.09)
Ballet dancers			
Time to maximal force in landing (s)	0.10 (0.02)	0.10 (0.01)	0.09 (0.01)
Volleyball players	0.11 (0.02)	0.11 (0.01)	0.09 (0.02)
Ballet dancers			

4. Discussion

The primary purpose of the study was to evaluate the symmetry of the unilateral CMJ among female volleyball players and ballet dancers. The results showed an average asymmetry of 13.36% between the dominant and non-dominant leg among volleyball players, while the ballet dancers had no significant asymmetries (4.26%). In the volleyball group, the leg asymmetry index was greater than 10% among 67% of volleyball players who showed a difference between the dominant and non-dominant leg, indicating muscular imbalances/asymmetries [16]. Asymmetry between the two legs up to 9.3 % difference among female volleyball players was reported by Soylu et al. [33] and up to 14.26 % by Fort et al. [34], and addressed as a contralateral deficit. It is suggested that the magnitude of jump asymmetry of 10–15% can be considered as a reference value for female volleyball players Fort et al. [34] and should be kept in these range if the potential risk of injury is to be reduced and performance on the court optimized [6, 20].

Our sample of volleyball players, despite the obtained values were within reference values [34], shows a considerable difference between the performance of the dominant and non-dominant leg, which could be due to the nature of training that does not encourage alternating single-leg jumps, rather focuses more on the technique of receiving and hitting, which allows players to choose their take-off leg. Our results can thus be explained by the sport-specific training background. Typically, team athletes use the same leg for the jumps and similar movements [20]. Since the jump height and the speed of the attacking hit represent the two main components in volleyball, the muscle performance of the players must be high. A high jump guarantees the advantage for the attack and block, which means that the jump height directly affects the success of the player [10]. Jump height differs between players, with younger athletes having smaller jumps (25.2 (4.4) cm) Nikolaidou et al. [18], reported that professional volleyball players achieve a bilateral vertical jump height of 25.2 (4.4) cm, Agopyan et al. [10] reported 42.5 (4.19) cm, while Meylan et el [20]. reported 16.87 (2.94) cm in female recreational athletes. Our group of non-professional young volleyball players CMJ was with 27 cm in the range of younger athletes as reported by Nikolaidou et al. [18]. Besides height of the jump the landing phase is an important part of the performance and has the highest risk for injuries. Majority of landings in women's volleyball occur in the unilateral position [12], therefore, analysis of the landing phase of the vertical jump provides insight into the control of landing deceleration and amortisation. Present results did not indicate any asymmetry in the landing phase.

Unlike volleyball players, ballet dancers do not show differences between the dominant and non-dominant leg. The explanation for this could be that the focus of ballet training is on symmetrical strengthening of the leg, where exercises are first performed with the dominant leg and then repeated with the non-dominant leg [35]. This explains the lack of difference between the dominant and non-dominant leg of ballet dancers. Lin et al. [35] found that especially novice dancers do not show the difference between the dominant and non-dominant leg, while experienced dancers have better control of the dominant leg and also achieve better results. Vertical jumps in classical ballet are in the external rotation of the hip. The height of the vertical jump is smaller in the external rotation position of the hip than in the neutral position because the knee extensors and abductors of the hip develop less force [36]. Wyon et al. [9] tested professional ballet dancers and recorded an average vertical countermovement jump height of 50.8 (7.9) cm, with soloists reaching as high as 55.3 (5.0) cm. Our group of non-professional young ballet dancers CMJ was with 25 cm considerably lower compared to reported CMJ height of professional ballet dancers. Similarly, to volleyball players group also the ballet group did not indicate any asymmetry in the landing phase.

A difference in leg symmetry prior to injury is an important risk factor for injury and is also commonly used as a parameter for determining full return to sport following lower extremity injury or surgery. If leg power was asymmetric at baseline in single-leg dominant athletes, attempting to achieve muscular symmetry between the legs could mislead the rehabilitation protocol [3]. Unfortunately, there is not enough evidence to determine which is the most effective rehabilitation approach after an injury and the best time to return to sport to prevent re-injury [3]. It is also not clear which training strategy is more effective to overcome the asymmetry, some reported unilateral training was efficient [37] and the other offered support for the bilateral training [38]. A general recommendation is that athletes with a leg injury should achieve symmetrical bilateral between the injured and uninjured leg, as indicated by a difference of less than 15%, before returning to sport [3].

The comparison between the two groups of young female athletes reviled that on average, volleyball players from our sample jumped higher than ballet dancers, especially when bilateral jumps were tested. The difference between the groups could be a result of the amount of weekly training, which is 18% higher on average for the volleyball players. It is possible that volleyball training specifically focuses on building muscles important for jump execution, and that volleyball players generally jump higher than ballet dancers. Comparing our results to data from other studies, we have found that both volleyball players and ballet dancers jump higher than recreational athletes [20] and people who do not participate in sports [22]. Due to more intense training, professional volleyball players and ballet dancers generally jump higher than non-professionals such as the participants in our study [9, 10]. Moreover, the amount of used energy also differed between the two groups. It was 59% higher in volleyball players because they outweighed ballet dancers by an average of 16% and therefore had to lift a larger body mass. The results suggest that muscle power was significantly higher in our group of volleyball players, considering that vertical jumps predict well the value of muscle performance and are a reliable indicator of the difference in muscle performance between different groups [17]. Landing phase, on the other hand, did not differ between the two groups, suggesting that the ability to control landing with one or both legs is not solely dependent on muscle power. A controlled eccentric contraction of the ankle, knee and hip muscles is required for landing [15]. The reported results differ between the studies. Ortega et al. [39] reported that time to maximum force during landing was 0.045 (0.013) s for semi-professional soccer players and 0.54 (0.016) s for recreational male athletes [27]. Both of our groups used more time to reach maximum force during landing, indicating greater absorption. The reason for this could be gender, training, or the fact that participants were not given specific instructions for landing. When preferred landing strategies are allowed, participants tend to expend more energy and do more negative work than necessary [40]. Soft landing in non-disabled individuals is primarily a function of motor control and can be voluntarily controlled [27].

It would be interesting to compare male ballet dancers and volleyball players, as male dancers in ballet play a more significant role in jumps and therefore they pay more attention to jump training in their training [9]. Males naturally exhibit better muscle power, therefore both male ballet dancers and volleyball players will jump higher than female ballet dancers and volleyball players. On the other hand, Maulder and Cronin [17] and Meylan et al. [24] reported that male athletes have a much lower height difference than females for jumps performed with the dominant or non-dominant leg.

Limitations of this study include a small sample of participants, the fact that the volleyball players and ballet dancers were not professionals, and that the two groups did not complete the same amount of weekly training. The amount of training could have affected CMJ parameters. However, it might not necessarily influence the symmetry of the one legged CMJ. Further research is needed to address the problem of contralateral deficit in elite athletes as well.

5. Conclusion

Ballet dancers showed more symmetrical height, power, and energy of the unilateral vertical CMJ jump compared to the volleyball players, who showed a significant contralateral deficit. These results pointed out the need to assess symmetry between the dominant and non-dominant leg in among volleyball players and design muscle training accordingly. On average, volleyball players showed more power and used more energy compared to the ballet dancers for the CMJ. Volleyball players jumped slightly higher than the ballet dancers with the dominant leg and significantly higher for a bilateral vertical CMJ. The obtained results suggest that the training regime for volleyball players should focus on overcoming the differences in muscle performance asymmetry. We can suggest that volleyball players introduce the training of jumps for both legs in the way ballet dancers train to try to overcome the contralateral deficit that is a consequence of the sport-specific training background.

Declarations

Author contribution statement

Jereb V: Conceived and designed the experiments; Performed the experiments; Analyzed and interpreted the data; Contributed reagents, materials, analysis tools or data; Wrote the paper.

Vauhnik R: Analyzed and interpreted the data; Wrote the paper.

Rugelj D: Conceived and designed the experiments; Analyzed and interpreted the data; Contributed reagents, materials, analysis tools or data; Wrote the paper.

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Data availability statement

Data will be made available on request.

Declaration of interest's statement

The authors declare no conflict of interest.

Additional information

No additional information is available for this paper.

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