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There Is No Cross Effect of Unstable Resistance Training on Power Produced during Stable Conditions

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Featured Application: Though both the long-term and acute effect of instability resistance exercises on lower and upper body muscle power and strength has been widely investigated, the cross-transfer effect of these exercises on power produced during traditional resistance exercises on stable surfaces has yet to be fully examined. Our study revealed no cross effect of instability resistance training on power outputs under stable conditions. This confirms and complies with the principle for specificity of training. If one is aiming to specifically improve strength at high contraction velocities then unstable surfaces should not be included in resistance training.

Abstract: This study evaluates the effect of 8 weeks of the stable and unstable resistance training on muscle power. Thirty-three healthy men recreationally trained in resistance exercises, randomly assigned into two groups, performed resistance exercises either under stable or unstable conditions for 8 weeks (three sessions per week). Before and after 4 and 8 weeks of the training, they underwent squats and chest presses on either a stable surface or on a BOSU ball and a Swiss ball respectively with increasing weights up to at least 85% 1RM. Results showed significant improvements of mean power during chest presses on a Swiss ball at weights up to 60.7% 1RM after 4 and 8 weeks of the instability resistance training. Mean power increased significantly also during squats on a BOSU ball at weights up to 48.1% 1RM after 4 but not 8 weeks of instability resistance training. However, there were no significant changes in mean power during bench presses and squats on a stable support surface after the same training. These findings indicate that there is no cross effect of instability resistance training on power produced under stable conditions. This confirms and complies with the principle for specificity of training.

Keywords: Swiss ball; squats; muscle power; chest presses; BOSU ball

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1. Introduction

Combining strength training with instability seems to be an efficient form of workout for prevention and rehabilitation of injuries, however it actually might be less beneficial for improvement of the ability to produce maximum force in the shortest time [1,2]. While these exercises can improve physical fitness in recreationally trained individuals [3–6], the controversy still exists about their effectiveness for improvement of neuromuscular performance in athletes. Discrepancies can be mainly observed in acute and/or adaptive changes in muscle strength and power, as well as electromyographic (EMG) muscle activity in response to exercises performed under unstable conditions [7–18]. For instance, one of the former studies revealed that unstable surface training using inflatable balance discs attenuates an improvement in athlete's performance [19]. The authors suggest that unstable surface training would be the best utilized in the upper body, which typically operates in an open-chain fashion in the majority of sporting movements. Conversely, similar interventions could prove to negatively affect performance in the lower extremities, which typically operate in a closed-chain fashion in most athletic activities. Similarly, more recent studies have reported limited effectiveness of instability resistance training on proxies of athlete performance (e.g., straight-line sprint speed, planned and reactive agility, countermovement jump, drop jump, trunk muscle strength/activation, balance, aerobic capacity, the ball kicking speed) over exercises performed under stable conditions [20–22].

The main argument is that isometric force (about 30–70%), rate of force development (40.5%) and power (59%) are lower during exercises, such as dumbbell chest presses [23], deadlifts [24], leg extensions, plantar flexions [25] and squats [26,27] performed on an unstable than a stable surface. Values of force, velocity and power are also lower during dynamic chest presses (6–10%) [28,29] and squats (16%) [29] under unstable conditions. Because of this, resistance exercises on a stable support base have been recommended for improvement of muscle strength and athlete performance [26,30]. The requirement of 80% of the maximum muscle strength for its improvement in trained subjects [31] is not achieved during resistance exercises on unstable surfaces [26,30].

Nonetheless, resistance exercises on unstable surfaces are a great tool for functional training. Unlike conventional strength training, instability resistance training addresses both postural and core stability [32–34]. Its main feature is a more pronounced activation of stabilizing muscles. This may be demonstrated by increased EMG activity of trunk-stabilizing and other muscles involved in a given exercise under unstable conditions, such as curl-ups [35], chest presses [36,37], push-ups [38], seated overhead shoulder presses [39], side-bridges [40], single-leg holds and press-ups [33] and squats [26,41]. It is therefore very likely that a greater challenge to the neuromuscular system is induced by unstable than stable resistance exercises. They may potentiate the neural adaptation of stabilizing trunk muscles and thereby improve core stability [42–44].

However, the question remains as to whether these beneficial effects of instability resistance exercises can be transferred in traditional resistance training on a stable support base and thereby enhance neuromuscular performance. Specifically, the extent to which unstable resistance training contribute to power enhancement during traditional resistance exercises needs to be investigated. Greater muscle power can contribute to both general (e.g., sprinting, jumping) and sport-specific skills (e.g., a stronger, longer and faster soccer kick) while simultaneously reducing the risk of injury.

To address this question, we evaluated changes in upper and lower body power outputs at different weights after 4 and 8 weeks of the traditional and instability resistance training in individuals practicing conventional resistance exercises. We hypothesized that these changes will be not transferable across conditions over 8 weeks of the training. We also assumed that pre-training differences in power production under stable and unstable conditions diminishes later during chest presses when compared to squats.

2. Materials and Methods

2.1. Participants

A group of 33 healthy men recreationally trained in resistance exercises were recruited. They had ~5 years' experience with traditional resistance exercises but not with resistance exercises on unstable surfaces. Subjects were eligible if they had been involved with resistance training for at least 6 months with regular barbell bench presses and barbell squats as part of their training 2–3 times per week. Exclusion criteria covered sustained pain or injury of the back, pelvis, lower or upper limb during the last 6 months, or having diseases affecting their neuromuscular functions. Preliminary measurements were conducted to match participant pairs for age, height, body mass and strength (1RM under stable conditions). They were then randomly assigned to either stable (SG) or unstable (UG) groups. There was no observed difference in training experience between these groups. The 1RM did not differ significantly between groups neither during chest presses (83.1 ± 9.1 W and 81.7 ± 8.7 W, respectively) nor during squats (126.4 ± 14.3 W and 123.0 ± 12.5 W, respectively). Both groups underwent a 8-week resistance training, however the SG under stable (n = 17, age 22.1 ± 1.9 y, height 181.9 ± 6.4 cm, body mass 83.4 ± 9.6 kg) and the UG under unstable conditions (n = 16, age 21.8 ± 2.2 y, height 183.0 ± 7.2 cm, body mass 79.9 ± 8.9 kg). Participants were required to avoid from any vigorous workouts in the 48 h preceding the testing day. Participants were informed of the main purpose and design of the study and provided the informed consent. The procedures followed were in accordance with the ethical standards as laid down in the 1964 Helsinki Declaration and its later amendments.

2.2. Experimental Protocol

Participants underwent resistance training for 8 weeks (3 sessions a week). The SG performed barbell bench presses and barbell squats on a stable surface, whereas the UG performed barbell chest presses on a Swiss ball and barbell squats on a BOSU ball (1st week: day 1—chest presses, day 2—squats, day 3—chest presses, 2nd week: day 1—squats, day 2—chest presses, day 3—squats, etc.). The training program was designed to improve muscle power. Participants performed exercises with countermovement using maximum effort in the concentric phase. They were instructed to perform each exercise with increasing weights up to the one at which maximal values of power were achieved during testing sessions before and after four weeks of the training. Maximal values of mean power in the concentric phase of resistance exercises are usually achieved at 50–60% 1RM under stable and 40–50% 1RM under unstable conditions [45,46]. Using higher weights during unstable chest presses and particularly during unstable squats may increase fear of falling and thereby compromise the proper technique of movement. However, instability resistance exercises that uses lower forces, can increase strength in untrained and recreationally active young subjects similar to those with stable machines using heavier loads [5]. Numbers of repetitions were also set before and after four weeks of the training (8–10 repetitions at lower weights and 3 to 6 repetitions at higher weights, with 2 min of rest between sets; 5 to 4 sets at lower weights and 3 to 2 sets at higher weights). Preliminary findings revealed that power during chest presses decreases below 90% of its maximum after four repetitions when performed on the bench and after two repetitions on a Swiss ball [47]. Furthermore, the power falls below this limit after seven repetitions of squats on a stable surface and after four repetitions on a BOSU ball [47]. In order to increase maximal power, 2 to 3 repetitions are recommended for training in the Pmax zone (45–60% 1RM maximizes power during the jump squat and bench throw) and 3 to 5 or 6 repetitions in the general and ballistic power zone (30–45% 1RM) [48]. Higher repetitions (e.g., 8–10) with lighter resistances should be performed for learning technique [48]. Within a familiarization session, the training design was explained and trial exercises were performed. Emphasis was given to proper exercise techniques on unstable surfaces. All exercise sessions were supervised by members of the research team. Adherence to the exercise program was registered and regularly encouraged.

An assessment of muscle power was carried out before and after 4 and 8 weeks of the training. Prior to testing, a standardized warm up protocol was undertaken. Afterwards, participants performed in random order a) chest presses on a bench, b) chest presses on a Swiss ball, c) squats on a stable surface, and d) squats on a BOSU ball. They were instructed to perform all exercises with maximum effort in the concentric phase. The weight lifted of 20 kg was increased by 10 kg or 5 kg (at higher loads) up to 85% of their previously determined 1RM in stable conditions. As shown previously, muscle EMG activity and 1RM strength do not differ significantly during chest presses on a stable surface and an unstable exercise ball [8]. Two minutes of rest between repetitions were allowed for each weight lifted. The highest value of power obtained during 3 or 2 (at higher loads) trials was taken for evaluation.

When chest presses were performed, participants lowered the barbell to the chest, without contacting it in the transition phase, and then pressed it up. Repetitions that failed to come within 5 cm of the chest or contacted the chest were ignored and repeated after 1 min rest. The barbell movement distance was monitored by means of the FiTRO Dyne

Premium. Participants were asked to keep the same width of the grip for the whole test protocol and to maintain the contact between the bench and their back and hips. The Swiss ball was placed in the thoracic area while the feet were positioned on the floor during unstable chest presses.

Squats were performed from full extension to a 90° knee angle followed by an immediate upward movement with a barbell holding on the back. Participants were asked to keep the same position of the foot for whole test protocol. They stood on the bladder side of a BOSU ball to ensure similar conditions as during unstable chest presses. As shown, EMG data acquired from particular muscles does not differ significantly during single-leg standing on either side of a BOSU ball [49]. An assistant stood behind participants to avoid a fall.

Variables involved in chest presses and squats were registered by means of the FiTRO Dyne Premium (FiTRONiC, Slovakia). Variables obtained were demonstrated to be reliable during biceps curls and squat jumps [50], deadlifts to high pull with free weights and on the Smith machine [51], standing cable wood chop exercise [52], as well as chest presses on a Swiss ball and the bench [53]. This device was positioned on the floor and attached to the barbell by a nylon tether. Participants performed resistance exercises while pulling on this nylon tether. Peak and mean values of force, velocity and power in both the eccentric and concentric phase of resistance exercises were obtained. The distance by barbell covered was also recorded. However, only mean power in the concentric phase of lifting was analyzed in the present study.

2.3. Statistical Analysis

The SPSS statistical program for Windows, version 24.0 (SPSS, Inc., Chicago, IL, USA), was used. A priori power analysis with an assumed Type I error of rate 0.05 and a Type II error rate of 0.20 (80% power) indicated a sample size of 14 individuals per group [29,45,53]. To achieve sufficient participant enrolment and reach the target sample size, 20% was added to allow for dropouts. The data were analyzed using a 2-way ANOVA with repeated measures. Factors included time (pre-training vs. post-training) x training (stable resistance training vs. unstable resistance training). Chest presses were analyzed separately from squats. When significant differences were revealed ($p \leq 0.05$), a Tukey post hoc test was used. Effect sizes considered as large (>0.80), medium (0.50–0.79), small (0.20–0.49) and trivial (0–0.19) [54] are reported in the tables. Significant pre-post training changes and/or between-group differences are marked with a symbol (* $p \leq 0.05$). Descriptive statistics include mean and standard deviations (SDs).

3. Results

In total, data of 33 healthy men recreationally trained in resistance exercises were analyzed. One subject in UG did not complete the training program. There were no significant pre-training differences in power outputs between the SG and UG under both stable and unstable conditions.

3.1. Pre-Post Training Changes in Upper and Lower Body Muscle Power

Results of upper and lower body muscle power under unstable and stable conditions before and after 4 and 8 weeks of the instability resistance training are presented in Tables 1–4. There were significant improvements of mean power during chest presses on a Swiss ball at weights 20–40 kg after 4 weeks and at weights 20–50 kg after 8 weeks of the instability resistance training. However, no significant changes were observed in mean power produced during bench presses after the same training.

Mean power during squats on a BOSU ball increased significantly also after 4 weeks at weights 20–60 kg but not after 8 weeks of the instability resistance training. However, its values did not change significantly when squats were performed on a stable support base after the same training.

Table 1. Mean power (W) during chest presses on a Swiss ball prior to and after 4 and 8 weeks of instability resistance training.

Load (kg)	Pre-Training Mean (SD)	After 4 Weeks [a] Mean (SD)	After 8 Weeks [b] Mean (SD)	*p*-Values [a]	Effect Sizes [a]	*p*-Values [b]	Effect Sizes [b]
20	299.6 (27.1)	324.7 (32.7)	366.1 (36.1)	0.035	0.79	0.004	1.20
30	347.8 (37.6)	373.8 (42.0)	409.0 (43.8)	0.030	0.97	0.008	1.13
40	381.7 (31.8)	405.5 (33.1)	441.8 (35.9)	0.041	0.73	0.007	1.05
50	390.9 (35.8)	413.4 (35.4)	455.2 (33.9)	0.056	0.63	0.003	1.21
60	384.4 (35.0)	397.8 (38.8)	416.9 (39.9)	0.363	0.49	0.286	0.49
65	317.6 (36.9)	330.5 (37.6)	347.7 (36.5)	0.421	0.35	0.301	0.46
70	222.9 (38.0)	237.6 (42.1)	253.7 (44.8)	0.351	0.49	0.345	0.37

[a]—Changes in Mean Power before and after 4-Week Training, [b]—Changes in Mean Power from 4-Week to 8-Week Training.

Table 2. Mean power (W) during bench presses prior to and after 4 and 8 weeks of instability resistance training.

Load (kg)	Pre-Training Mean (SD)	After 4 Weeks [a] Mean (SD)	After 8 Weeks [b] Mean (SD)	*p*-Values [a]	Effect Sizes [a]	*p*-Values [b]	Effect Sizes [b]
20	312.1 (33.7)	327.4 (34.5)	350.0 (43.2)	0.341	0.45	0.004	0.58
30	365.2 (35.4)	380.6 (33.6)	400.9 (39.5)	0.333	0.45	0.311	0.55
40	396.7 (41.8)	421.9 (43.2)	443.4 (42.8)	0.254	0.59	0.276	0.50
50	430.1 (37.6)	450.9 (40.5)	471.8 (41.6)	0.309	0.53	0.298	0.51
60	448.3 (43.5)	470.1 (42.4)	487.4 (45.2)	0.263	0.51	0.293	0.39
65	421.8 (36.5)	435.3 (40.4)	449.0 (46.3)	0.360	0.35	0.408	0.32
70	335.5 (36.0)	348.2 (33.5)	356.6 (32.7)	0.414	0.53	0.570	0.25
75	246.9 (34.3)	263.1 (35.3)	270.1 (31.9)	0.288	0.47	0.581	0.21

[a]—Changes in Mean Power before and after 4-Week Training, [b]—Changes in Mean Power from 4-Week to 8-Week Training.

Table 3. Mean power (W) during squats on a BOSU ball prior to and after 4 and 8 weeks of instability resistance training.

Load (kg)	Pre-Training Mean (SD)	After 4 Weeks [a] Mean (SD)	After 8 Weeks [b] Mean (SD)	*p*-Values [a]	Effect Sizes [a]	*p*-Values [b]	Effect Sizes [b]
20	246.1 (29.0)	317.4 (34.4)	330.1 (38.3)	0.001	2.92	0.389	0.35
30	289.4 (31.9)	363.6 (40.0)	377.2 (42.8)	0.001	2.05	0.351	0.45
40	333.4 (41.5)	401.1 (45.4)	425.7 (49.3)	0.001	1.56	0.135	0.52
50	389.5 (41.9)	445.5 (43.4)	462.8 (48.2)	0.012	1.31	0.234	0.38
60	434.8 (47.9)	483.3 (49.9)	502.1 (51.2)	0.021	0.99	0.208	0.37
70	417.7 (46.6)	453.6 (48.7)	467.3 (43.2)	0.060	0.75	0.345	0.30
80	398.6 (43.5)	421.1 (46.5)	433.5 (48.5)	0.111	0.70	0.425	0.26

[a]—Changes in Mean Power before and after 4-Week Training, [b]—Changes in Mean Power from 4-Week to 8-Week Training.

Table 4. Mean power (W) during squats on a stable support base prior to and after 4 and 8 weeks of instability resistance training.

Load (kg)	Pre-Training Mean (SD)	After 4 Weeks [a] Mean (SD)	After 8 Weeks [b] Mean (SD)	*p*-Values [a]	Effect Sizes [a]	*p*-Values [b]	Effect Sizes [b]
20	303.1 (41.8)	331.5 (49.9)	343.9 (48.7)	0.253	0.62	0.578	0.25
30	345.7 (44.6)	375.6 (49.9)	389.1 (52.4)	0.201	0.63	0.512	0.26
40	396.7 (46.2)	421.0 (49.6)	429.5 (49.7)	0.260	0.51	0.634	0.17
50	454.6 (45.5)	477.3 (48.3)	496.2 (50.1)	0.290	0.48	0.467	0.38
60	508.1 (43.9)	528.8 (45.4)	548.1 (49.9)	0.412	0.46	0.450	0.40
70	539.5 (50.8)	561.4 (52.6)	579.6 (55.4)	0.314	0.42	0.466	0.34
80	529.5 (50.2)	553.8 (53.1)	576.1 (59.8)	0.271	0.47	0.320	0.39
85	507.8 (45.5)	529.0 (47.4)	553.3 (58.5)	0.322	0.46	0.278	0.45
90	493.4 (46.7)	515.5 (52.3)	534.0 (55.0)	0.283	0.45	0.471	0.35
95	445.5 (48.5)	467.7 (51.8)	488.1 (54.6)	0.285	0.44	0.422	0.38

[a]—Changes in Mean Power before and after 4-Week Training, [b]—Changes in Mean Power from 4-Week to 8-Week Training.

3.2. Between-Group Differences in Muscle Power Prior to and after 4 and 8-Week Training

A comparison of maximal values of power at a weight of 50 kg showed significantly higher mean power during chest presses on the bench in the SG than on the Swiss ball in the UG before and after 4 weeks but not after 8 weeks of the training (Figure 1a). Pre-training maximal values of power at a weight of 60 kg were also significantly higher during squats on the stable support base in the SG than on the BOSU ball in the UG, whereas there were no significant differences after 4 and 8 weeks of the training (Figure 1b).

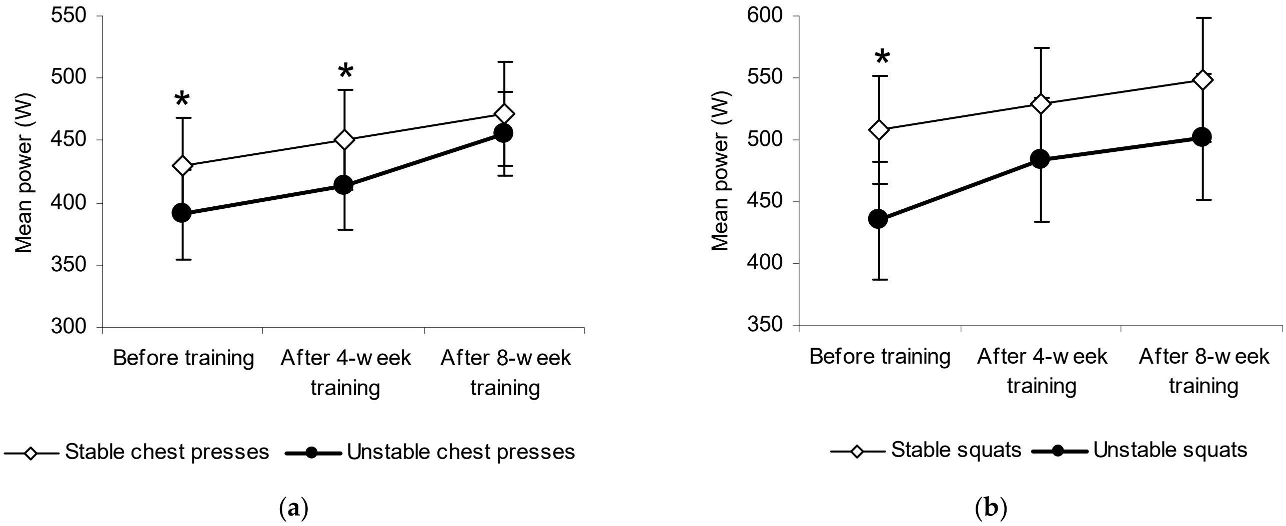

Figure 1. Maximal values of mean power during (**a**) chest presses and (**b**) squats before and after 4-week training under stable and unstable conditions.

4. Discussion

Findings revealed significant increase in power outputs during unstable chest presses at weights 20–40 kg after 4 weeks and at weights 20-50 kg after 8 weeks of the instability resistance training. Power outputs also increased during squats on a BOSU ball at weights 20–60 kg after 4, but not after 8 weeks of the instability resistance training. However, the values did not change during bench presses or squats on the stable support surface after the same training. A between-group comparison revealed that significant stable to unstable differences in power outputs before the training disappear after 8 weeks of chest presses and after 4 weeks of squats.

Lower pre-training values of power during resistance exercises on unstable than on stable surfaces are in agreement with previous studies. A recent systematic review by Marquina [55] reported that instability decreases muscular power, strength and speed in adults when compared to stable conditions. However, compromised muscle power during instability resistance exercises was only found at higher weights, i.e., ≥60% 1RM [29]. The power decline was more evident for unstable chest presses than unstable squats when performed in an interval mode (6 sets of 8 reps with 70% 1RM) [56]. Reduced power during unstable chest presses may be attributed to the delayed transition phase of the stretch-shortening cycle (SSC). The SSC activation enhances muscle power while lifting a weight [57]. This includes the energy storage of elastic components and the stimulation of the stretch reflex. If the coupling time is too long, elastic energy may be lost as heat and the stretch reflex is not fully activated [58]. Instability resistance exercises may compromise all SSC phases, in particular the transition phase. Around this phase maximum force is produced. To provide the support for contracting muscles, individuals must stabilize their body on an unstable surface. This task may affect the contraction of muscles acting on the barbell. Their less intensive contraction prolongs the transition time and, because of lower peak force, also affects elastic energy accumulation. This results in lower velocity and power produced in the concentric phase of instability resistance exercises [45].

However, significant differences in mean power during chest presses under stable and unstable conditions were also found after 4 weeks of training. The bench press is a sport-specific skill learned by athletes in the autonomous stage of motor learning [59]. It is most likely that resistance trained individuals performed this task largely automatically with minimal demands on cognitive processing. Therefore only muscles involved in this specific movement are contracting, thus the power produced by them during initial weeks of training is higher as compared to those performing on an unstable surface. On the other hand, chest presses on the Swiss ball were not performed by athletes before and therefore this motor skill is in the cognitive stage of motor learning [59]. This new task was inconsistent and inefficient and required considerable attention in individuals with no experience with instability resistance exercises. Many muscles are contracting during this exercise, though not all of them are involved in the chest press motion, but they may relieve the work of muscles that are involved. Many other muscles also contract to keep the body balanced on an unstable surface. This is a new skill and therefore the power during initial weeks of the training was smaller. As the athlete become more familiar with chest presses on an unstable Swiss ball, the movement also becomes more efficient. Their repetitive performance during training sessions led to an increase in muscle power. Interestingly, this power enhancement from the 4th to 8th week of the training was much faster during chest presses on an unstable surface with greater muscle involvement in work when compared to bench presses. This may be demonstrated by no significant differences in muscle power during stable and unstable chest presses after 8 weeks of training.

With respect to squats, the power was also significantly higher under stable than unstable conditions, but only prior to the training. Its steep increase was observed during the initial 4 weeks followed by slower improvement within the 8 weeks of the training. The squat on a stable surface is a sport specific skill learned by athletes in the autonomous stage of motor learning [59]. Similar to during bench presses, it is most likely that resistance trained individuals performed this motor task effectively and consistently. Therefore only muscles involved in this specific movement are contracting, thus the power produced by them during initial weeks of training is higher as compared to those performing under unstable conditions. However, the squat on an unstable surface is also not a new exercise because it is performed by athletes during movements on natural unstable surfaces (grass, sand, etc.). Therefore the dynamic stereotype of squats on the BOSU ball is learned much better than chest presses on the Swiss ball. This can explain a lack of significant differences in power produced during stable and unstable squats. This confirms and complies with the principle for specificity of training [60–62].

However, these instability resistance exercises are very similar to those performed on a stable support base. Therefore training using unstable surfaces could lessen the proper exercise performance on the stable surface due to impaired dynamic stereotype of this movement under stable conditions. This could contribute to no significant changes in muscle power during squats and chest presses on the stable support base in the group that underwent instability resistance training. Similarly, Sparkes and Behm [5] reported no significant differences after 8-week training on unstable and stable surfaces, though there was a trend for the UG to enhance the stable-to-unstable chest press force ratio to a higher level than the SG. This may be ascribed to greater stress on the neuromuscular systems under unstable conditions and thus greater training adaptations [63,64]. Contrary to this, the lower force, power and movement velocity [1,2,23,34,65–68] associated with instability resistance exercises can result in less rigorous power and strength adaptations. However, there are also studies that did not demonstrate the force reduction under unstable conditions [3,8,28]. Besides the type of exercise (i.e., chest press versus squat) and the instability device used (i.e., the more compliant Swiss ball versus the stiffer BOSU ball providing different levels of task difficulty), also number of sets and repetitions, the weight used and rate of loading may induce load- and velocity-specific training adaptations under unstable conditions [69]. For instance, lower loads applied during training on unstable surfaces provides sufficient stimuli to ensure similar power or strength training gains as compared to training on stable surfaces using higher loads [5]. It is most likely that the group who trained bench presses and squats on a stable surface was able to exert themselves at higher contraction velocities throughout training sessions and thereby received more specific training stimuli for power development. However, the group that performed resistance exercises on unstable surfaces trained very probably at lower velocities due to the requirements for balance control. Therefore if the one is aiming to specifically improve muscle power then unstable exercise balls or wobble boards should not be included in resistance training. A review by Behm et al. [70] showed that the application of strength training on unstable surfaces compared with the one under stable conditions has limited additional effects on muscle power, strength and balance in adolescents and young adults.

The limitation of our study is that the sample consisted of healthy recreational resistance exercise trained individuals and therefore findings might not be applicable for elite athletes. Though instability resistance training may not be sufficient to stimulate the required adaptations in competitive athletes, it can induce the improvement of neuromuscular performance in non-elite and recreational athletes [3–6,13,71–73]. However, in some cases, no significant between-group differences after the training under stable and unstable condition may be observed [6,10,72]. Athletes who train on some kind of unstable surfaces (grass, sand, etc.) may be able to learn faster when compared to those exercising on a stable support base. Athletes incorporating instability devices into their training routine may also produce greater power outputs during lower and upper body resistance exercises as opposed to those practicing only conventional resistance exercises. These findings has to be taking into account when unstable platforms and implements are added to resistance exercises. In particular, stages of motor skills learning and the specific movement dynamic stereotype of instability resistance exercises should be considered when they are implemented in training programs.

5. Conclusions

Findings revealed that significant stable to unstable differences in power outputs prior to the training disappear following 8 weeks of chest presses and following 4 weeks of squats. This effect may be attributed to a greater improvement of muscle power after instability than traditional resistance training in individuals undergoing resistance exercises on a stable surface. However, there is no cross effect of instability resistance training on power outputs under stable conditions. This confirms and complies with the principle for specificity of training. If the one is aiming to specifically improve strength at high contraction velocities then unstable surfaces should not be included in resistance training.

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Data Availability Statement: Data are available upon request.

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