The Effect of Several Weeks of Training with Mini-Trampolines on Jump Performance, Trunk Strength and Endurance Performance

**Summary**

› The aim of the present study was to examine the effect of a jumping-fitness training on mini-trampolines on endurance capacity, trunk strength and reactive jump performance. 21 healthy, untrained volunteers were separated into two groups: an intervention group (n=12: age 22±1 years, BMI 22.6±2.6kg/m²) and a control group (n=10: age 25±3 years, BMI 22.8±4.3kg/m²).

› The participants in the intervention group completed an eight-week standardized jumping training on mini-trampolines with three training sessions (TS) per week on average. The control group received no intervention. Pre- and post-tests included a treadmill-test and a jumping-test to examine reactive jump performance (drop jump). Furthermore, trunk strength was measured using an isometric maximum test. Additionally, heart rate (HR), energy expenditure and perceived exertion (BORG 6-20) were monitored during all TS.

› After eight weeks of intervention jumping group showed significant increases in running speed at V4 and isometric maximum strength in trunk extension. Changes in jump performance were not significant (p>0.01). A nonsignificant group*time interaction was found (p=0.05). Control group showed no significant increase in all parameters (p>0.05). Participants of intervention group trained at 83±4% compared to their maximum heart rate. The mean perceived exertion was 14.2±2.2 (somewhat hard/hard) and decreased over intervention period.

› The results show, that standardized jumping training on minitrampoline is a vigorous conditioning training and should be controlled on the effectiveness.

**KEY WORDS:**

Trampoline Exercise, Jumping, Endurance, Trunk Strength

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**Introduction**

The fitness industry in Germany is experiencing continual market growth. According to the DSSV (German Employers’ Association in Fitness and Health Facilities), the number of memberships in fitness studios rose from 9.46 to more than 10 million in 2017 (16). The Second B2B Survey of Fitness Trends in Germany showed that an increasing number of highly qualified offers, fitness programs for senior citizens, sports programs to promote health in the workplace, training for weight reduction, and guided group fitness programs have established themselves within the top 5 trends available on the German fitness market. In 2016, fascia training, jumping, suspension training, and deepWORK® (functional group training) were the most commonly mentioned personal fitness trends (19). In 2017, jumping was ranked among the German top 40 (20).

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**Zusammenfassung**

› Ziel der vorliegenden Studie war es, die Auswirkungen eines mehrwöchigen Jumping-Fitness-Trainings auf Minitrampolinen auf die Ausdauerleistungsfähigkeit, Rumpfkraft sowie reaktive Sprungkraft zu untersuchen. Dafür wurden 21 gesunde, untrainierte Probanden einer Interventionsgruppe (N=12: Alter 22±1 Jahre, BMI 22.6±2,6kg/m²) und einer Kontrollgruppe (N=9: Alter 25±1 Jahre, BMI 22.7±1.6kg/m²) zugeordnet.


› Es zeigten sich nach acht Wochen Intervention signifikante Verbesserungen der Laufleistung bei V4 und der isometrischen Maximalkraft der Rumpfextension (p<0.01) in der Jumping Gruppe. Die Veränderungen der Sprungleistung war nicht signifikant (p=0.01). Die Kontrollgruppe zeigte keine signifikanten Veränderungen (p=0.05). Ein signifikanter Interaktionseffekt zwischen Gruppe und Zeit lag nicht vor (p>0.05). Die Interventionsgruppe trainierte im Durchschnitt bei 83±4% der HF max und verbrannte 9.7±2,5kcal/min. Die subjektive Anstrengung lag im Mittel bei 14±2 (etwas anstrengend/anstrengend) und reduzierte sich über den Interventionszeitraum.

› Die Ergebnisse zeigen, dass ein standardisiertes Sprungetrainung mittels Trampolinen ein intensives Konditionstraining ist, welches durch weitere Untersuchungen auf Effektivität hin zu untersuchen ist.

**SCHLÜSSELWÖRTER:**

Trampolin-Fitness, Springen, Ausdauer, Rumpfkraft
Jumping-Fitness is a workout in which various slow, fast, and intensive jumps are combined with classical aerobic steps on a mini-trampoline accompanied by music. In contrast to conventional trampoline jumps, here the upper body is bent over and held still, while only the legs carry out the jumping movements. This form of trampoline workout is considered to be gentle on joints with high energy expenditure, and is presumed to be effective for training the abdomen, legs, buttocks, and deep back muscles. It is also considered effective for endurance training (24). Existing studies on trampolining show that biomechanical load while jumping on a trampoline is lower than during jogging at the same heart rate (4). It has also been found that, for comparable oxygen intake, the physical work on a trampoline is 68% greater than on a treadmill. McGlone et al. (2002) found that jumping on a mini-trampoline with comparable perceived exertion as during running resulted in similar cardiopulmonary load for both activities (32). The measured heart rates, maximum oxygen intake (VO\(_{2\text{max}}\)), and energy expenditure (9.45±1.75kcal/min) were analogous. Burandt et al. (2016) also found similarly high values for energy expenditure (6). Sahin et al. (2016) showed that regular aerobic training on a mini-trampoline was more effective in improving VO\(_{2\text{max}}\) than jogging. However, heart rates recorded during training on the mini-trampoline were 15% higher than during running (37). In addition, regular training on a mini-trampoline significantly increased jump height (2, 25, 37). Compared to a running group and a control group, trampolining resulted in a significant reduction of body fat (1, 37). Currently, there is no evidence of that trampolining effects back strength (25). Studies on the effects of trampolining as a fitness program are rare, and the results are difficult to compare due to varying jump techniques. Some of the studies implemented solely intensive jogging, which is only part of the jumping workout. So far, no meaningful effects on trunk strength (anterior and lateral abdominal muscles) have been found. Based on current findings, we hypothesized that eight weeks of standardized, guided jumping training on a mini-trampoline results in significant increases in aerobic capacity, trunk strength, and reactive jumping power. The purpose of the present study, therefore, was to examine the effects of an eight-week training program on these physiological dimensions.

### Methods

#### Sample

21 healthy subjects unaccustomed to the training regimen used in this study were included. Subjects were assigned to an intervention group (IG, N=12: 10 female, 2 male; 22±4 years, BMI 22.6±2.6kg/m²) or a control group (CG, N=9: 6 female, 3 male; 22±4 years, BMI 22.7±4.6kg/m²).

#### Experimental Setup and Training Regimen

An incremental test of aerobic capacity on a treadmill, as well as tests for reactive jumping power, trunk strength, and body composition were conducted pre and post the eight-week intervention. The control group did not receive any specific intervention, and the intervention group was exposed to a jumping exercise regimen (three times per week) on a mini-trampoline guided by an instructor. Post-tests were conducted during the same time of day as the pre-test within one week of completing the intervention period.

Trampoline exercise sessions were standardized using an instructional video and carried out using a mini-trampoline (Jumping® Profi Standard Plus, München, Germany). The 19-minute video (CYBERMOVES-Clip, CYBERCONCEPT, Münster, Germany) was accompanied by seven different songs. Each training session consisted of a 2:52 minute warm-up with mobilisation and low-impact jumps, a 14:30 minute main section with low and high impact jumps, and a one-minute cool-down with low intensity jumps.

The first session (S1) was used for subjects to become accustomed to the mini-trampoline and to practice different types of jumps. Starting with the second session (S2), the training regimen was carried out under the supervision of a certified instructor. In total, IG completed 24 sessions (S1-S24).

#### Data Collection Procedures

The following tests were conducted before (PRE) and after (POST) the eight-week intervention period:

- **Aerobic capacity** was defined as the treadmill speed (m/s) at blood lactate levels of 2mmol*l\(^{-1}\) (V2) and 4mmol*l\(^{-1}\) (V4), with the treadmill set at 1% incline, starting at 6km*h\(^{-1}\) with increments of 2km*h\(^{-1}\) every 4 minutes. V2 and V4 were calculated by linear interpolation of recorded blood lactate levels.

- **Trunk strength on extension (kg)** and flexion (kg) was assessed using tests of isometric maximal force (TONUS Easy-Torque, Zemmer, Germany). The maximum isometric strength was measured. The maximum of three repeated trials was used for analysis and normalized to body weight.

- **Jump force** was assessed using a drop jump test (no arm involvement, 30cm initial height) onto a contact mat (SMART-JUMP, Fusion Sport, Nottingham, UK) to determine contact times (CT) and jump height (JH). Given CT and JH, the index of reactive strength (RSI = JH/CT) was calculated (35). Out of five repeated jump trials, the trial with minimum CT was chosen for further analysis.

- **Body composition** was quantified using bioelectric impedance analysis (BIA) using a body composition analyzer (TANITA BC-418 MA, Illinois, USA). It was calculated the body weight, body fat and muscle mass.

In addition to PRE and POST test recordings, heart rate (HR), energy expenditure, and physical exertion were assessed in each of the 24 trampoline training sessions (S2-S24).
Heart rates and energy expenditure were recorded using heart rate monitors (Polar® FT4 und Polar® FT7, Germany), which gave heart rates readings (HR) and estimates of the total energy expenditure during a training session. According to manufacturer information, anthropometric data, HR, and HRmax were used to estimate energy expenditure.

Physical exertion was quantified objectively using the mean heart rate during training sessions, averaged across the sessions, and normalized to HR max. In nine out of twelve subjects, HRmax occurred during the trampoline sessions, whereas HR max recordings were taken from the treadmill tests for the remaining three subjects. Perceived physical exertion data were collected using a BORG Scale (score 6-20) (5).

### Statistical Analysis

Descriptive statistics (mean, SD, range) were calculated for each variable. The mean differences were showed in Box Plots. For each subject, PRE-POST differences were calculated and normalized to the subject’s mean. Normal distribution of the differences was assessed using the Shapiro-Wilk test. PRE-POST differences were analyzed using a Wilcoxon Signed Rank-Test. For the group*time interaction, differences between groups pre and post intervention were analyzed using the Mann-Whitney-U-Test. Statistical significance was set at $\alpha = 0.05$ and a Bonferroni-Holm correction was applied for multiple tests. This resulted in a corrected $\alpha$ of 0.01 for individual tests. In addition to significance testing, Cohen’s d was used as a measure of effect size. Primary clinical endpoints were assessed using the surrogate variables V2, V4, trunk strength, and RSI. Body composition and perceived physical exertion were considered as secondary clinical endpoints and only analyzed descriptively. The figures are made with Grapher™ 4.0 (Golden Software, Colorado, USA). All statistical procedures were carried out using SPSS 16 (IBM, Germany).

### Results

Data from 21 subjects (IG=12, CG=9) were available for analysis (Table 1). No statistically significant between-group differences were found for aerobic capacity, RSI, or trunk strength before intervention (PRE).

We found a nonsignificant PRE-POST increase in V2 ($p=0.055$) and a statistically significant PRE-POST increase in V4 for the intervention group ($p=0.005$), however both effect sizes can be considered small (Table 1). V2 and V4 did not change for the control group ($p>0.05$).

Similarly, small (nonsignificant) PRE-POST effects in the intervention group were found for RSI ($p=0.031$) and JH ($p=0.05$) (Table 1). No PRE-POST changes were found for CT in the intervention group ($p=0.08$). No PRE-POST changes for reactive jumping power variables were found in the control group ($p<0.05$).

We found a statistically significant increase and large effect size for trunk extension ($p=0.003$) and a nonsignificant increase in trunk flexion ($p=0.04$) with medium effect size. A nonsignificant change in trunk extension ($p=0.038$) was found for the control group. We found no between-group differences in POST ($p>0.05$).

### Table 1

<table>
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<tr>
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<th>INTERVENTION GROUP</th>
<th>CONTROL GROUP</th>
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<tr>
<td></td>
<td>PRETEST</td>
<td>POSTTEST</td>
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<td><strong>Anthropometry</strong></td>
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<td>(17-26.7)</td>
<td>(171-25.7)</td>
<td>(16.3-30)</td>
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<td>26.5±5.4%</td>
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<td>(18.4-35.1)</td>
<td>(12.1-36.4)</td>
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<td>MM</td>
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<td><strong>Endurance performance</strong></td>
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<tr>
<td>V2</td>
<td>6.4±1.2km/h</td>
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<td>(4.9-8.8)</td>
<td>(5.8-8.3)</td>
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<tr>
<td>V4</td>
<td>8.2±1.4km/h</td>
<td>8.7±1.4km/h</td>
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<td><strong>Reactive jump performance (drop jump)</strong></td>
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<td>RSI</td>
<td>0.9±0.24</td>
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<td>CT</td>
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<td>(150-256)</td>
<td>(157-310)</td>
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<td>JH</td>
<td>16.9±3.3cm</td>
<td>18.2±3cm</td>
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<td><strong>Isometric force</strong></td>
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<td>Trunk flexion</td>
<td>0.56±0.08kg/KG</td>
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<td>(0.34-0.67)</td>
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<td>Trunk extension</td>
<td>1±0.22kg/KG</td>
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<td>(0.58-1.39)</td>
<td>(0.95-1.7)</td>
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The Effect of Training with Mini-Trampolines

Discussion

This form of jump training is a fitness trend which aims to improve aerobic capacity and strength, but only few studies have been conducted in this context. The aim of this study was to examine the effects of an eight-week training program with a mini-trampoline on aerobic capacity, reactive jumping power, and trunk strength. No significant group*time interaction effect was found. Significant improvements were found in aerobic capacity for V4 and for trunk strength in the intervention group. Reactive jumping strength showed a nonsignificant increase. The significant changes in the intervention group may be a random effect. Studies have shown that jump training or trampolining improve aerobic capacity and jumping power. However, to date, these effects have not been confirmed for commercially developed fitness training programs.

Significant improvements in running performance with increases in VO$_{2\text{max}}$ after training on a mini-trampoline for several weeks were found in a previous study with comparable training frequency (37), as well as in a study with considerably greater training frequency (five times) and intervention period (eleven weeks) (17). It can be concluded, therefore, that standardized training three times a week for eight weeks with a mini-trampoline can improve aerobic capacity in untrained persons. Following an 11-week intervention in women at intensities between 70-85% HR$_{\text{max}}$, Edin et al. (1990) found a 4.4% improvement in VO$_{\text{max}}$, and Sahin et al. (2016) found 7.8% improvements in VO$_{\text{max}}$ at an intensity of 75% HR$_{\text{max}}$ (17, 37). In the present study, subjects trained at 83±4% HR$_{\text{max}}$, which represents a comparable load. According to Scribbans et al. (2016), improvements in aerobic capacity can be achieved across a wide range of training intensities (38).

Studies have shown that the oxidation of pyruvates and fatty acids for energy production is optimized by repetitive, long-lasting exercise due to increased muscle capacity (3, 33). This can be attributed to an increase in mitochondrial proteins, resulting in increased activity of oxidative enzymes (36). Two weeks of high intensity training were able to increase the citrate synthase activity by 43% (41). An eight-week training program on a treadmill, for example, induced not only qualitative, but also quantitative improvements in the mitochondria (44). Following twelve weeks of ergometer training, Konopka et al. (2014) measured an increase in mitochondrial proteins (26). Long-lasting jumping exercise on trampolines appears to induce similar effects. Improved running performance during the incremental tests can therefore be attributed to economizing effects of mini-trampoline training on aerobic glycolysis, which still needs to be investigated on the cellular level. At the same intensity, which was realized using video guidance, perceived exertion decreased. Here, the BORG scale was used to assess perceived exertion, as it is considered to be reliable (28) and correlates closely with physiological variables (HR, lactate, and VO$_2$ intake) (5, 21, 29).

The reduced perceived exertion can be explained by an economization of the aerobic metabolism, as well as through improved coordination in jumping technique and sequence of motions.

As already used in other studies, the drop jump provides information about the reactive jump performance (42). In the intervention group, jump performance in the drop jump showed an improvement in RSI (+12.2%). The increase in reactive jump strength is based on improved jump height (+7.7%). Studies using conventional trampolines for training found significant increases in jump height in trained men and children after twelve weeks (25), eight weeks (37), and as early as after four weeks (2) of intervention with three sessions per week, respectively. Trampolining therefore improves jump performance, which is primarily shown by an increase in jump height. No effects on contact time were found in this study. It is possible that the elastic trampoline surface prevents the muscle’s extension-contraction cycle (ECC) from being used optimally to improve its contraction speed and strength. Studies have shown that plyometric training of the lower extremities has performance-improving effects (i.e. jumping power, speed) (30). Training interventions on non-rigid surfaces have shown similar results. The jump training implemented here is characterized by quick, short contact times on the elastic surface and requires a quick and powerful hip flexion. With regard to RSI, the present...
study found positive though nonsignificant effects on reactive jumping performance. The contact times, however, showed ambiguous effects on muscle function in ECC. Future studies, particularly studies on ECC function, should also examine effects with regard to muscle activation and reflex response.

There is currently little research on changes in trunk strength after running and jumping exercises on a trampoline. Karakollukçu et al. (25) had 20 male gymnasts perform various jumps on mini-trampolines (flips, vertical jumps) three times a week for twelve weeks and found no effects on back strength. Cho et al. (9) found significant improvements in dynamic lumbar stability following a 6-week intervention of stationary running, whereby another study presents contradictory results (39). In our study, subjects in the jumping group were only able to significantly increase maximum isometric strength for trunk extension (+26%). Only a medium effect in trunk flexion increase was found in our data (+10.7%). These subjects carried out jumps similar to aerobic exercises while keeping their trunk bent forward. Muscle activity varies depending on upper body position. Greater trunk flexion increases torque and activity in the back extensor muscles (23). Other authors reported no increase in antagonist co-contraction at submaximal isometric strength measurements of trunk extension (31). Increased EMG activity of the trunk flexors was only seen at greater loads (10, 31). The increased upward movement of the knee toward the sternum (similar to a reverse crunch), particularly during high-impact jumps (i.e. Stomping, Side to Side, 1&1, 2&2), causes increased loading of the trunk flexors. Within the context of classical strength training, this and other similar movement patterns imply high EMG activity in the upper and lower portions of the rectus abdominis and rectus femoris muscles (18).

The small increases within the control group can, in part, be interpreted as habituation effects. Remarkably high increases in trunk extension strength were found for two subjects. While seven subjects showed no changes (on average +0.08kg/KG), two subjects achieved improvements of 0.47 and 0.26kg/KG.

Body composition in the intervention group showed reduced BF (-5.4%). As BF was not a primary endpoint in this study, no significance test was carried out. BF should be examined separately. The increased upward movement of the knee toward the sternum (similar to a reverse crunch), particularly during high-impact jumps (i.e. Stomping, Side to Side, 1&1, 2&2), causes increased loading of the trunk flexors. Within the context of classical strength training, this and other similar movement patterns imply high EMG activity in the upper and lower portions of the rectus abdominis and rectus femoris muscles (18).

The authors have no conflict of interest.

Conflict of Interest
The authors have no conflict of interest.

References


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