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# ENHANCING JUMP GROUND REACTION FORCES IN CHILDREN THROUGH JUMP TRAINING

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***ABSTRACT***

*Plyometric training is a popular form of exercise training and is often included in exercise programmes and tests for children. As such, the aim of the study was to determine the effect of different types of plyometric jumps on jump performance in children. Forty children were randomly assigned into either one of three experimental groups: Group 1, mean age 13.80±1.23, (training based on jumps) (JUM); Group 2, mean age, 13.50±0.97 (training based on hops) (HOP); Group 3, mean age, 13.90±1.20 (training based on box drills) (BOX); Group 4, mean age 13.90±1.20 (non-exercising control group) (CON). Training lasted nine weeks. Jump ground reaction forces were assessed using: counter-movement jump (CMJ), continuous jump with bent legs (CJb) and drop jump (DJ). This study elicited significant ($p \leq 0.05$) improvements in jump height in all test jumps (CMJ, CJb and DJ) in the JUM, HOP and BOX. Furthermore, the JUM and HOP resulted in increases in jumping power during CMJ and CJb with only the BOX improving jump power during the DJ. Only the JUM resulted in significant increases in jump force during the CMJ. These improvements following simple jumps requiring minimal equipment strongly support the use of jump training to enhance athletic performance in children.*

**Key words:** Jump intervention; Plyometric training; Jump performance; Children; Stretch-shortening exercises.

## INTRODUCTION

Plyometric training is a popular form of exercise training (Markovic & Mikulic, 2010), and is often included in exercise programmes and tests for children and adolescents (Taylor *et al.,* 2010). In this regard, plyometric training is considered a safe and effective mode of training for children (Johnson *et al.,* 2011). Plyometric training of children has demonstrated to elicit positive changes in the neural and musculo-skeletal systems, muscle function and athletic performance and to reduce injuries in children (Markovic & Mikulic, 2010).

Leg muscle power and jump performance are considered essential factors for successful completion of daily living activities (Bassey *et al.*, 1992), occupational tasks (Kraemer *et al.*, 2001) and athletic performance (Bobbert, 1990; Canavan & Vescovi, 2004). In terms of athletic performance, plyometric training has been shown to increase kicking distance and improve balance, agility, ability to jump and run in children (Kontulainen *et al.*, 2002; Markovic & Mikulic, 2010; Johnson *et al.*, 2011). According to Kontulainen *et al.* (2002), jump training can increase the mineral density of bones in girls, which is essential since childhood is a critical time to enhance bone mass and strength (Bailey *et al.*, 1999; MacKelvie *et al.*, 2003).

## RESEARCH PROBLEM

There is limited information available regarding the type of plyometric training required to improve jump performance in children (Diallo *et al.*, 2001; Taylor *et al.*, 2010). In addition there is limited information about the adaptability of children with respect to different workloads and the differences in performance among the various types of jumps (Bassa *et al.*, 2011). Therefore, the aim of the present study was to determine the training effect of different types of plyometric jumps on jump performance in children.

## METHODS

### Participants

Forty children (12 boys and 28 girls) participated in this study (Table 1). Sample size was calculated using PS Power and Sample Size Calculation version 2.1.30. The power of the study was set at 80% with a confidence level of 95%, while the standard deviation observed was 0.06 (Bobbert *et al.*, 1986). Differences in population means were set at 0.08 and the estimated sample size was 10 participants per group.

***TABLE 1*: BASELINE DESCRIPTIVE (Mean±SD) DATA OF PARTICIPANTS**

| **Variables** | **Jump-train. Gr. (JUM)** (n = 10) | **Hop-train. Gr. (HOP)** (n = 10) | **Box drill-train. Gr. (BOX)** (n=10) | **Non-exercise Gr. (CON)** (n=10) |
|---|---|---|---|---|
| Age (years) | 13.80±1.23 | 13.50±0.97 | 13.90±1.20 | 13.90±1.20 |
| Height (cm) | 152.90±4.32 | 152.90±6.63 | 151.35±7.74 | 152.07±6.55 |
| Weight (kg) | 46.10±5.23 | 44.30±4.71 | 48.44±12.55 | 47.28±9.78 |
| BMI ($kg \cdot m^{-2}$) | 19.67±1.50 | 18.93±1.37 | 20.95±4.29 | 20.39±3.51 |

Participants were stratified by gender and randomly assigned using a random numbers table for either 1 of 3 experimental groups: Group 1 (training based on jumps) (JUM); Group 2 (training based on hops) (HOP), Group 3 (training based on box drills) (BOX) and Group 4 (non-exercising group) (CON) served as a control group. Ethical clearance was obtained from the Universiti Sains Malaysia's institutional review board. Each participant's parents/guardians signed an informed consent form, while the participants themselves also gave consent. All participants underwent a screening history before participation and were informed of all possible experimental risks and discomforts of participating in this investigation.

As inclusion criteria for participation, the following requirements were set: to be sedentary; aged between 13 to 17 years; free from any serious injury and health problems prohibiting exercise; have a stature above 140cm; have a body mass of more than 30kg; have a body mass index (BMI) of between 15.0 and 29.9 $kg.m^{-2}$; and have no history of plyometric training. There were no significant ($p>0.05$) differences between intervention and non-exercising control group with respect to age, stature, body mass and body mass index (BMI). Each group consisted of 3 boys and 7 girls. Each participant was requested: not to exercise before the testing session; schedule study visits at the same time of the day for both sessions; and to wear the same athletic shoes for each session.

**Anthropometric measurements**

After informed consent procedures were completed, body mass and stature were measured to the nearest 0.01kg and nearest 0.25cm measured using a SECA body meter (SECA, Model 707 1314004, Vogel & Halke, Hamburg, Germany). In addition to measuring the body mass and stature of the participants, these indices were used to calculate BMI for descriptive purposes.

**Ground Reaction Force measurements**

Participants were, in a random order, required to perform three types of jumps. The jumps performed were the counter-movement jump (CMJ) (Diallo *et al.,* 2001; Taylor *et al.,*2010), the continuous jump with bent legs (CJb) and the drop jump (DJ) (Diallo *et al.,*2001; Santos & Janeira, 2008). Force plate data were captured using a force platform (Quattro Jump one-component Force Plate System for Jump Performance Measurement in Sports, Type 9290AD, Kistler Instrumente AG Winterthur, Switzerland), and laptop (Hewlett Packard, Palo Alto, California, USA).

The counter-movement jump (CMJ) required the participant to stand upright for 1 to 2 seconds with hands resting on the hips (in an attempt to measure leg performance instead of arm performance). When instructed to do so, the participant jumped maximally. Participants then landed on the force plate and stood still for 1 to 2 seconds before once again jumping maximally. When performing the continuous jump with bent legs (CJb), each participant began in the upright position for 1 to 2 seconds with their hands resting on their hips. The participant then jumped 5 times continuously for maximum height. With every jump, the participant would bend their knees to approximately 90° during the contact phase, which was controlled by the research technician. No standing still period was required at the completion of the test. The drop jump (DJ) was performed from a 30.48cm high step-up box adjacent to the force plate. Participants were asked to step down from the box with their hands affixed to their hips (minimising the contribution of the arms), by landing with both legs on the force platform and jumped maximally before landing and remaining upright for 1 to 2 seconds. Each participant performed two trials for each type of jump at each testing session and the average from these trials was used for data analysis.

## Training programmes

Participants participated in a 9-week training programme consisting of either training based on jumps (JUM), hops (HOP) or box drills (BOX), in accordance with the guidelines of the National Strength and Conditioning Association (Baechle & Earle, 2000), and other recommendations (Bobbert, 1990; Johnson *et al.*, 2011) (Table 2). Prior to participation, the participants were familiarised with the equipment and the correct plyometric techniques, especially to ensure an effective amortisation phase. The familiarisation involved 12 warm-up jumps and then a number (4±2 trials) of increasingly higher intensity jumps on until the participant felt comfortable with the techniques. The participants were asked to replicate the procedures on the second testing session, which occurred within 7 days of the first session.

***TABLE 2*: SUMMARY OF INTERVENTION PROGRAMME**

| **Jump-training Gr. (JUM)** (n=10) | | **Hop-training Gr. (HOP)** (n=10) | | **Box-drill-train. Gr. (BOX)** (n=10) | |
|---|---|---|---|---|---|
| **Jumping exercises** | Sets x Reps | **Hopping exercises** | Sets x Reps | **Box-jump exercises** | Sets x Reps |
| Squat jump | 2x10 | Double leg hop | 2x5 | Box jump-single response | 2x10 |
| Split squat jump | 2x8 each leg | Side hop | 2x10 | Depth jump | 2x10 |
| Star jump | 2x8 | Front cone hops | 2x10 | Single leg push off | 2x20 |
| Rocket jump | 2x8 | Cone hops with 180 degree turn | 2x8 | Alternating push off | 2x20 |
| Split squat with cycle | 2x10 | Single foot side-to-side ankle hop | 2x10 | Lateral box jump | 2x10 |
| Standing jump over barrier | 1x10 | Side-to-side ankle hop | 2x10 | Side-to-side box shuffle | 2x10 |
| Standing jump and reach | 1x6 | Single leg hop | 2x10 | Lateral step-up | 2x15 each leg |
| Scissors jump | 2x8 | Diagonal cone hops | 2x5 | Front box jump | 2x10 |
| Pogo | 2x10 | Two foot ankle hops | 2x10 | Jump to box | 2x10 |

Reps= Repetitions

Participants trained as follows: for 1 hour per session once weekly for week 1 to 3; twice weekly for weeks 4 to 6; and thrice weekly for weeks 7 to 9. Each session included a warm-up (15 minutes), a main part consisting of 9 exercises (35 minutes) performed maximally and had a 1to 3 minute rest period between each set and a cool-down (10 minutes). As plyometric exercises were performed to each participant's maximal effort, relative intensity remained consistent for the 9 weeks and allowed individual progression and the ability to cope with the plyometric exercises initially. This uniform intensity combined with the 35-minute exercise duration ensured a standardised plyometric programme for each participant. No intervention programme was administered to the control group. All participants in the control group were advised not to participate in any other regular physical exercises and to continue with their normal activities of daily living throughout the 9 weeks.

### Statistical analysis

All jump height, jump power and jump force data were screened for normality assumptions using the Shapiro-Wilks test and histograms where the normality curve was used to indicate whether the data was normally distributed. Differences in measurements were compared using a one-way analysis of variance (ANOVA) and statistical significance set at $p \leq 0.05$. Pre-test, mid-test 1 (assessed at week 3), mid-test 2 (assessed at week 6) and post-test data were reported as means±standard deviations. Included in the statistical analyses was the utilisation of percentage change to illustrate relative changes observed from pre- to post-test for each of the plyometric programmes. Data were analysed using the Statistical Package for Social Sciences (SPSS) Version 14.0 (Chicago, IL).

## RESULTS

### Jump Height

Table 3 shows the jump height for the counter-movement jump (CMJ), the continuous jump with bent legs (CJb) and the drop jump (DJ) during pre-test, mid-test 1, mid-test 2 and post-test for the 4 groups involved in the study. In this regard, there were significant improvements in jump height when training was based on jumps (JUM) for CMJ, CJb and DJ. For the training group based on box drills (BOX), significant differences in jump height were found between tests in CMJ, CJb and DJ. There were significant differences in jump height in CMJ, CJb and DJ in the CON.

Further analysis of the jump height during the CMJ for the 4 groups indicated a significant improvement in jump height during mid-test 2 between the BOX and CON ($p<0.001$), JUM and CON ($p<0.01$), HOP and CON ($p<0.01$) and BOX and CON ($p<0.01$). During mid-test 1 a significant ($p<0.05$) difference was found for jump height during the CMJ between the HOP and CON and JUM and BOX.

For jump height for the 4 groups, a significant difference was found between the HOP and CON during mid-test 1 ($p<0.05$), mid-test 2 and post-test ($p<0.01$). There was also a significant difference between the BOX and CON during mid-test 2 ($p<0.05$) and post-test ($p<0.01$). The JUM and CON were found to be significantly different during post-test ($p<0.01$). For DJ there were no significant differences between the groups during pre-test, mid-test 1, mid-test 2 and post-test.

***TABLE 3*: MEAN±SD FOR JUMP HEIGHT DURING CMJ, CJb AND DJ DURING PRE-TEST, MID-TEST 1, MID-TEST 2 AND POST-TEST**

| **Groups** (n=10 in each) | **Pre-test (cm)** (M±SD) | **Mid-test 1 (cm)** (M±SD) | **Mid-test 2 (cm)** (M±SD) | **Post-test (cm)** (M±SD) | **Mean % change** |
|---|---|---|---|---|---|
| *Jump* | | | | | |
| CMJ | 26.89±4.37 | **29.25 ±4.08**** | **32.42±4.85†††,++** | **34.51±4.07‡‡‡,§§§,¤¤** | 28.34 |
| CJb | 23.30±4.85 | **25.32 ±5.07**** | **26.96±5.33††** | **30.52±5.79‡‡‡,§§§,¤¤¤** | 30.99 |
| DJ | 19.21±3.18 | 20.42 ±2.83 | **21.70±3.48†,+** | **24.41±5.44‡,§§,¤** | 12.96 |
| *Hop* | | | | | |
| CMJ | 26.04±6.77 | **31.09 ±6.86***** | **32.95±6.82†††,++** | **36.13±6.70‡‡‡,§§§,¤¤¤** | 38.75 |
| CJb | 24.70±4.85 | **27.42 ±5.23**** | **28.50±6.14††** | **29.98±6.44‡‡‡,§§,¤¤** | 21.38 |
| DJ | 20.71±3.57 | **22.71 ±4.32**** | **23.81±5.60†** | **26.23±7.33‡‡,§,¤** | 26.65 |
| *Box* | | | | | |
| CMJ | 27.81±5.17 | **31.03 ±4.97***** | **33.44±3.31††** | **35.41±3.32‡‡‡,§§,¤¤** | 27.33 |
| CJb | 24.47±4.69 | **26.71 ±4.88**** | **27.94±4.45††,++** | **30.06±3.76‡‡‡,§§,¤¤** | 22.84 |
| DJ | 18.79±3.43 | **22.61 ±5.00**** | **22.57±3.63†** | **26.05±4.67‡‡,§,¤¤** | 38.64 |
| *Control* | | | | | |
| CMJ | 28.11±6.18 | 28.15 ±5.25 | 27.62±5.55 | 29.40±4.54¤¤ | 4.59 |
| CJb | 22.54±4.26 | 22.97 ±4.29 | **23.90±4.61†** | **24.78±4.75‡,¤** | 9.94 |
| DJ | 18.01±3.92 | 18.98 ±3.95 | 19.88±4.00 | **20.72±3.82§** | 15.05 |

CMJ= Counter movement jump; CJb= Continuous jump with bent legs; DJ= Drop jump
M±SD= Mean±Standard deviation   Mean % change= Mean percentage change from pre- to post-test
**= Between pre and mid-test 1 ($p<0.01$);   += Between mid-test 1 and mid-test 2 ($p<0.05$);
***= Between pre and mid-test 1 ($p<0.001$);   ++= Between mid-test 1 and mid-test 2 ($p<0.01$);
†= Between pre and mid-test 2 ($p<0.05$);   §§= Between mid-test 1and post-test ($p < 0.01$);
§= Between mid-test 1and post-test ($p<0.05$);   ††= Between pre and mid-test 2 ($p<0.01$);
§§§= Between mid-test 1and post-test ($p < 0.001$);   †††= Between pre and mid-test 2 ($p<0.001$);
¤= Between mid-test 2 and post-test ($p<0.05$);   ‡= Between pre and post-test ($p<0.01$);
¤¤= Between mid-test 2 and post-test ($p<0.01$);   ‡‡‡= Between pre and post-test ($p<0.001$);
¤¤¤= Between mid-test 2 and post-test ($p<0.001$)

### Average Jump Power

Table 4 shows the jump power for CMJ, CJb and DJ during pre-test, mid-test 1, mid-test 2 and post-test for the 4 groups involved in the study. In the CON no significant differences were found in average jump power between any of the tests.

Further analysis also revealed that there were significant differences in average jump power during the CMJ between the JUM and CON ($p<0.01$), HOP and CON ($p<0.05$) during mid-test 1, whereas significant differences were found between the JUMP and CON ($p < 0.01$), HOP and CON ($p < 0.01$) and BOX and CON ($p < 0.05$). At post-test, a significant difference was found between the JUMP and CON ($p<0.001$), HOP and CON ($p < 0.001$) and BOX and CON ($p < 0.01$). However, no significant differences for average jump power were found for CJb and DJ during pre-test, mid-test 1, mid-test 2 and post-test were elicited between any of the groups.

***TABLE 4*: MEAN±SD FOR JUMP POWER DURING CMJ , CJb AND DJ DURING PRE-TEST, MID-TEST 1, MID-TEST 2 AND POST-TEST**

| **Groups** (n=10 in each) | **Pre-test W.kg$^{-1}$** (M±SD) | **Mid-test 1 W.kg$^{-1}$** (M±SD) | **Mid-test 2 W.kg$^{-1}$** (M±SD) | **Post-test W.kg$^{-1}$** (M±SD) | **Mean % change** |
|---|---|---|---|---|---|
| *Jump* | | | | | |
| CMJ | 20.37±2.92 | **22.08±3.43**** | **21.70±2.45†** | **22.25±2.73‡** | 9.23 |
| CJb | 17.93±2.06 | **20.19±1.91***** | **20.10±2.38†** | **20.79±2.61‡‡,¤** | 15.95 |
| DJ | 17.69±4.38 | 20.29±3.53 | 18.96±2.59 | 20.49±3.22 | 15.83 |
| *Hop* | | | | | |
| CMJ | 20.19±2.62 | 20.89±3.42 | 21.88±4.29 | **22.36±4.26‡,§** | 10.75 |
| CJb | 18.58±2.65 | **20.79±3.11**** | **21.03±4.32†** | **20.94±4.36‡** | 12.70 |
| DJ | 19.96 ± 3.22 | 20.18±3.23 | 21.30±4.33 | 22.27±5.31 | 11.57 |
| *Box* | | | | | |
| CMJ | 20.96±3.33 | 21.35±3.84 | 21.41±2.55 | **22.23±3.05‡** | 6.06 |
| CJb | 20.19±7.00 | 20.37±4.58 | **21.37±4.82+** | 20.75±2.15 | 2.77 |
| DJ | 18.61 ± 4.62 | **21.54±4.99**** | 21.41±5.10 | **23.16±7.71‡** | 24.44 |
| *Control* | | | | | |
| CMJ | 20.21±2.79 | 19.25±3.30 | 19.15±2.91 | 19.17±2.10 | 5.15 |
| CJb | 17.77±3.02 | 17.69±2.67 | 18.65±3.25 | 18.53±2.62 | 4.28 |
| DJ | 16.73±3.91 | 17.31±3.55 | 17.59±3.55 | 17.82±2.37 | 6.52 |

CMJ= Counter movement jump; CJb= Continuous jump with bent legs; DJ= Drop jump
M±SD= Mean±Standard deviation Mean % change= Mean percentage change from pre- to post-test
**: Between pre-test and mid-test 1 ($p<0.01$); +: Between mid-test 1 and mid-test 2 ($p<0.05$);
***: Between pre-test and mid-test 1 ($p<0.001$); §: Between mid-test 1and post-test ($p<0.05$);
†: Between pre-test and mid-test 2 ($p<0.05$); ¤: Between mid-test 2 and post-test ($p<0.05$);
‡: Between pre-test and post-test ($p<0.05$); ‡‡: Between pre-test and post-test ($p<0.001$)

## Jump Force

Table 5 shows the jump force for CMJ, CJb and DJ during pre-test, mid-test 1, mid-test 2 and post-test for the 4 groups involved in the study. The findings of the analysis indicated that there were significant differences in average force during the CMJ between mid-test 1 and mid test 2 ($p<0.05$), mid-test 1 and post-test ($p<0.05$), and during the CJb between pre- and mid-test 1 ($p<0.01$). However, no significant differences were found between the groups.

***TABLE 5*: MEAN±SD FOR JUMP FORCE OF CMJ, CJb AND DJ DURING PRE-TEST, MID-TEST 1, MID-TEST 2 AND POST-TEST**

| **Groups** (n=10 in each) | Pre-test %BW (M±SD) | Mid-test 1 %BW (M±SD) | Mid-test 2 %BW (M±SD) | Post-test %BW (M±SD) | **Mean % change** |
|---|---|---|---|---|---|
| *Jump* | | | | | |
| CMJ | 1.27±0.34 | 1.38±0.35 | **1.22±0.26+** | **1.16±0.14§** | 8.66 |
| CJb | 1.42±0.64 | **1.61±0.58**** | 1.38±0.72 | 1.19±0.48 | 16.20 |
| DJ | 1.31±0.66 | 1.66±0.86 | 1.15±0.59 | 1.07±0.45 | 18.32 |
| *Hop* | | | | | |
| CMJ | 1.19±0.51 | 1.05±0.24 | 1.07±0.29 | 1.06±0.27 | 10.92 |
| CJb | 1.22±0.66 | 1.32±0.58 | 1.18±0.37 | 1.09±0.40 | 10.66 |
| DJ | 1.37±0.71 | 1.20±0.47 | 1.31±0.57 | 1.27±0.48 | 7.30 |
| *Box* | | | | | |
| CMJ | 1.31±0.51 | 1.15±0.42 | 1.08±0.27 | 1.11±0.26 | 15.27 |
| CJb | 1.64±1.22 | 1.33±0.64 | 1.40±0.61 | 1.07±0.17 | 34.76 |
| DJ | 1.47±0.62 | 1.46± 0.60 | 1.54±0.64 | 1.45±0.89 | 1.36 |
| *Control* | | | | | |
| CMJ | 1.13±0.20 | 1.02±0.19 | 1.00±0.18 | 1.00±0.16 | 11.50 |
| CJb | 1.26±0.38 | 1.15±0.28 | 1.23±0.19 | 1.11±0.27 | 11.90 |
| DJ | 1.12±0.43 | 1.13±0.33 | 1.06±0.25 | 1.07±0.28 | 4.46 |

CMJ= Counter movement jump; CJb= Continuous jump with bent legs; DJ= Drop jump; BW= Body weight
M±SD= Mean±Standard deviation Mean % change= Mean percentage change from pre- to post-test
**=Between pre- & mid-test 1 ($p<0.01$); += Between mid-test 1 & mid-test 2 ($p<0.05$);
§= Between mid-test 1 & post-test ($p<0.05$)

## DISCUSSION

Although there have been numerous plyometric interventions that have shown to augment jump performance, there is a dearth of data about the adaptability of children between the various jump types when used for training. This study elicited improvements in jump height in all test jumps (CMJ, CJb and DJ) in the JUM, HOP and BOX. Further, the JUMP and HOP resulted in increases in jump power during CMJ and CJb with only the BOX improving jump power during the DJ. Interestingly, only JUM resulted in significant increases in jump force during the CMJ.

These findings are consistent with the statements of Markovic and Mikulic (2010), who state that plyometric training has the potential to enhance jump performance in children. Further, the results of the present study are support the findings of Meylan and Malatesta (2009), who found that an eight-week plyometric training programme using pubertal children (N=14) showed significant increases in jump height during CMJ (7.9%). Diallo *et al.* (2001) also found significant increases CMJ and squat jump performance following a 10-week jump programme using pre-pubertal boys (N=20) while Kotzamanidis (2006) found significant increases in squat jump performance following a 10-week jump programme using prepubescent boys (N=15). Similar to the present study, following an eight-week plyometric training programme using pre-pubertal boys and girls (N=60), Bassa *et al.* (2011) found significant increases in jump height for CMJ, while Santos and Janeira (2008) reported significant increases in CMJ and squat jump following a 10-week weight and plyometric training programme using boys aged 14 to 15 years old N=25). Interestingly, both Bassa *et al.* (2011) and Santos and Janeira (2008), did not find any significant improvements in jump performance during DJ. Furthermore, Santos and Janeira (2008) found that varied jump heights up to 50cm elicit no difference in performance gain.

The associated data demonstrating that jump power improved in the JUM and HOP groups following CMJ and CJb and in the BOX group following DJ, shows that jump power predominantly improved, while jump force only improved in JUM following CMJ. Thus, increases in strength and speed of the concentric-eccentric phase could explain the increases in jump power. Further, kinematic and speed efficiencies could also have resulted in jump height improvements since plyometric exercise improves both the elastic nature of the muscles and tendons involved in jumping, together with neurological responses, and enhances speed and power by exploiting the reflex processes in the muscles to produce a more powerful contraction (Zatiorsky, 1995). Since the control group also demonstrated significant improvements in jump height, learning could have resulted in improvements from one test to the next. In this regard, the improvements observed in the jump height of the CON group could be explained by a learning effect in addition to improved coordination, control and neuromuscular recruitment. However, the effects of learning in the experimental group can be diminished since all variables would have improved consistently in the experimental group and since all the participants underwent the same familiarisation tests and number of jumps during testing.

## CONCLUSIONS

The purpose of this study was to evaluate the effects of nine weeks of three different types of jump training on performance in children. The results of this study revealed that jump training produced beneficial changes in performance and these improvements in jump height, power and force adaptations, combined with the limited previous data strongly support the use of jump training to enhance athletic performance (jumping, sprinting, agility, etc.) in children. However, prior to participation, children should be adequately familiarised with the equipment and the correct plyometric techniques prior to embarking on such training.

## PRACTICAL APPLICATION

Training based on jumps and hops can elicit an increase in jump power, while training based on jumps increases jump force in children and as such could improve athletic performance through improved jump performance.

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