Chronic effect of strength training on vertical jump performance in parkour practitioners

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Authors' Contribution:
A Study Design
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Received: 19 November 2017; **Accepted:** 18 December 2017; **Published online:** 27 December 2017

AoBID: 11932

Abstract

Background & Study Aim: Parkour is a typical extreme form of physical activity (EFPA), commonly extreme sport. Parkour can be characterised as a high-intensity sport that demands motor actions like different jump techniques (vertical, horizontal, plyometric, long jumps), running, climbing, crawling and balancing. The aim of the present study was the effects of eight weeks of strength training on countermovement jump (CMJ) performance in parkour practitioners.

Material & Methods: Twenty parkour practitioners without any systematic strength training program experience were distributed into 2 groups. The strength training group (SG) performed strength, and conventional parkour training and the control group (CG) only performed the conventional parkour training. Both types of training were performed 2 times per week.

Results: The SG practitioners presented a significant increase in CMJ height ($p = 0.000194$), while the CG did not present a significant increase ($p = 0.138$). All SG practitioners showed a percentage increase in CMJ height, with a mean variation of 9.9 ± 0.9%.

Conclusions: Strength training increases the vertical jump height of parkour practitioners, which can positively influence performance in this modality. Therefore, the association of strength training with load protocol for muscular hypertrophy can increase the performance in parkour and should, therefore, be encouraged to the practitioners of this modality.

Keywords: extreme sports • muscle fibre • performance • strength training

Conflict of interest: Authors have declared that no competing interest exists

Ethical approval: The study was approved by the Ethical Committee for Research at the Federal University of Minas Gerais (approval reference number: 2.431.122)

Provenance & peer review: Not commissioned; externally peer reviewed

Source of support: Departmental sources

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Extreme sport – *noun* a sport considered more dangerous and thrilling than ordinary sports and often involving hazardous airborne stunts and tricks [18].

EFPA – "extreme form of physical activity are extreme sports, often classified according to the environment in which they are performed (water, land, air), extreme form of physical recreation as well as gainful activity or voluntary service, and all varieties of physical activity that meet at least one classification criterion of the feature associated either with extreme risk of injury or death, or extreme body burden with high level of effort, or extreme coordination difficulty" [19, see also 20].

Muscle strength – essential and basic physical capacity in combat sports by which the body moving status is modified [21].

Strength training – *noun* training that aims to build muscle strength, usually resistance training [18].

Chronic – *adjective* **1.** used for describing a disease or condition that lasts for a long time. Compare **acute 2.** used for describing severe pain [18].

Performance – *noun* the level at which a player or athlete is carrying out their activity, either in relation to others or in relation to personal goals or standards [18].

Muscle fibre – *noun* a component fibre of muscles (NOTE: There are two types of fibre, one forming striated muscles and one forming smooth muscles.) [18].

Neural – *adjective* relating to a nerve or the nervous system [18].

INTRODUCTION

Parkour can be characterised as a high-intensity sport that demands motor actions like different jump techniques (vertical, horizontal, plyometric, long jumps), running, climbing, crawling and balancing [1, 2]. Those particular movements commonly performed in parkour are based on jumping disciplines, gymnastics and track and field modalities [2]. To perform these actions, parkour requires a combination of different expressions of muscle strength, such as maximal and submaximal strength efforts in the upper and lower limbs to overcome urban and natural obstacles as efficiently as possible without external assistance equipment [2, 3]. Thus, the development of muscular strength capacity in this modality in specific actions can be determined for specific performance success.

The effectiveness in the performance of several techniques and in the obstacles to overcome in the specific practice of parkour is dependent on the performance in the horizontal and vertical jump [1, 3]. Countermovement jump (CMJ) is the most commonly used vertical jump technique in training sessions and in athletes' physical performance evaluations of various sport modalities [4] and its use is already well established in the literature [4-6].

CMJ performance is related with tasks that require the stretching-shortening cycle (SSC), high-speed racing skills, fast steering changes, falls followed by other actions (running, jumping, etc.) [6, 7], and actions presented in the parkour training routines. With the CMJ technique, strength training has been widely used in sports teams' physical training and became a reference training to improve abilities such as lower limb power, maximal force and maximal rate of force production [6-9]. This possible optimisation of the different types of muscle strength manifestations, due to neuromuscular adaptations, may be related to the improvement of the efficiency of the use of the SSC and probably to the increase of the performance of the CMJ.

Therefore, strength training can generate benefits for parkour practitioners, especially by increasing vertical jump height. However, no studies were found that investigated the chronic effect of strength training on performance in this modality.

The aim of the present study was the effects of eight weeks of strength training on countermovement jump (CMJ) performance in parkour practitioners.

MATERIAL AND METHODS

Participants

Twenty parkour practitioners, mean age 20.3 ±2.6 years, who were not involved in strength training volunteered to participate in this study. We considered untrained as those volunteers who had never participated in strength training. However, inclusion criteria were that subjects had been involved in parkour practice for at least two years (2 times per week for a minimum of 2 hours per day) and did not have any bone, articular or muscular injuries in the previous 6 months. Subjects were informed about the nature of this study and signed an informed consent form according to the International Review Board for the use of human subjects in research.

All procedures were approved by the Ethical Committee for Research at the Federal University of Minas Gerais (approval reference number: 2.431.122). None of the subjects smoked or were taking any medications or supplements while participating in the study.

The sample calculation was performed from the data of the pilot study, using the variable with the highest coefficient of variation (CV), performed by GPower 3.1 software. The effect size was fixed at 0.25, study power at 80% and the correlation between repeated measures at 0.75. The experimental design of the pilot study was the same as in the present study.

Proceedings

The volunteers were balanced and randomised distributed into two groups; the strength training group (SG) performed strength and conventional parkour training, and the control group (CG) only performed the conventional parkour training.

Familiarization Procedure

At the beginning of the intervention, the volunteers participated in the familiarisation process with CMJ. The initial procedures were performed on the Jumptest vertical jump mat (Hidrofit Ltda; Belo Horizonte, Brazil, the precision of 0.1 cm), connected to Multisprint software (Hidrofit Ltda; Belo Horizonte, Brazil).

A standard warm-up session was performed at the beginning of each familiarisation session, during which the individual walked at 6 km/h on a plane surface for 5 min and then performed 3 series of 3 CMJs. A 30-s break was allowed between the series. After the standard warm-up, a CMJ series was performed, with 1-min breaks between the attempts until the performance stabilised. The performance was considered stabilised when a sequence of 8 jumps was similar to the performance achieved previously with a sequence of 8 jumps [5].

CMJ Test

The CMJ test was performed pre- and post-training periods. The pre-training test was performed 48 hours after the familiarisation, respecting the same standard warm-up and CMJ technique described in the familiarisation. Each volunteer performed four CMJs with a 1-minute interval between each jump [4]. The mean of the four jumps was considered to determine the CMJ heights for each volunteer. The post-training test followed the same protocol and was performed 72 hours after the last training session. To determine the chronic effect of strength training on CMJ performance, the pre- and post-training means of the groups were compared.

Strength training protocol

Two days after CMJ pre-training, the SG practitioners initiated the strength training; they performed two training sessions per week, with a minimum interval of 72 hours between sessions, for eight weeks. During the training intervention, all volunteers maintained the practice routine of parkour. The volunteers were instructed not to perform the two trainings on the same day. The CG did not perform strength training, only parkour practice. Both types of training were performed twice a week. The strength training protocol consisted of 4 sets of 10 maximum repetitions of upper, lower and core exercises. The exercises were performed with an interval of 1 minute between sets and exercises. The strength training protocol was determined from the ACSM guidelines [10]. The exercises (performed in this sequence) were: back squat, seated leg extension, seated leg curls, machine hip adductions, machine hip abductions, standing calf raises, back lat pulldowns, seated rows, bench press, incline bench press, biceps curls, triceps pushdowns, back press, back extension, and sit-ups [11].

Statistical Analysis

The Shapiro-Wilk test verified the data normality. In addition to inferential statistics, descriptive statistics of the data were calculated (mean and standard deviation). To verify the reliability of the measurement of the force tests, intraclass correlation coefficient (ICC) and standard measurement error (EPM) tests were performed. To compare the means of CMJ performance pre- and post-training, in both groups, the paired t-test was used. The same test was used to verify the CMJ familiarisation data. The level of

Table 1. CMJ height pre and post-training of the strength training group.

Volunteers	CMJ pre-training (cm)		CMJ post-training (cm)	
	Mean	SD	Mean	SD
1	38.6	0.4	40	1.4
2	36.3	0.8	42.3	0.6
3	36.4	1	39.4	0.9
4	40.5	1.7	43.9	1.5
5	28.9	0.7	31.9	0.9
6	31.3	1.3	31.4	1
7	41.9	1.8	43.7	0.9
8	46.4	0.9	49.2	0.6
9	48.1	0.8	52.4	0.5
10	49.5	1.2	55	0.6
Group mean	**39.8**	**1.1**	**43.6***	**0.9**

*Significant difference to pre-training ($p<0.05$).

Table 2. CMJ height pre and post-training of the control group.

Volunteers	CMJ pre-training (cm)		CMJ post-training (cm)	
	Mean	SD	Mean	SD
1	31.6	1.3	32.3	1.3
2	43.2	1.4	40.8	1.1
3	39.5	1.1	40.1	0.5
4	38.1	0.7	37.8	1.4
5	40.2	0.7	39.1	0.4
6	33	0.6	32.6	0.9
7	36.4	0.8	36.3	1.3
8	26	0.3	25.8	0.1
9	33.5	0.6	33.1	0.7
10	34.3	0.7	34.6	0.9
Group mean	**35.6**	**0.8**	**35.3**	**0.9**

significance was fixed at 5% ($p<0.05$). To verify the effect of the training on the CMJ height, the effect sizes, with classification according to Rhea [12], were calculated. Statistical analysis of the data was performed using GraphPad Prism software (version 7.02).

RESULTS

All data presented normal distribution. The ICC value of all CMJ tests was 0.924, while the EPM value was 1.59%. The SG volunteers had a mean increase of 3.9 ±0.9 cm in their CMJs (Table 1). This improvement was statistically significant ($p = 0.000194$). All strength training group (SG) volunteers showed an increase in CMJ height, with the mean percentage increase of 9.9 ±0.9%. The control group (CG) volunteers did not show significant differences in mean CMJ height ($p = 0.138$) (Table 2).

DISCUSSION

After eight weeks of strength training, the SG showed a significant improvement in jump height, which confirmed the hypothesis of the study. The effect size presented by the SG group in relation to the CMJ height was 2.95, indicating a high training effect, according to Rhea [12]. The effect size presented by the CG for the same indicator was –0.4, which indicated a trivial (weak) effect of the training performed [12].

In general, the ability to produce force by the muscle is differentiated into three categories: maximal strength, maximal rate of force development and resistance [7, 8]. Muscle strength performance is dependent on the maximal amount of force a muscle fibre (fibre) produces per cross-sectional area, the rate of shortening of fibres (cross-bridge cycling rate), and the amount of energy that muscle fibre is able to turn into work muscle fibres, among others [13, 14]. The following chronic adaptations are expected in strength training: changes in the recruitment of motor units, synchronisation of muscular motor units and morphological (structural) adaptations, such as increased cross-sectional area [8, 13, 14]. The results of the present study showed that strength training produced an increase of CMJ performance. The effects of 8 weeks of strength training and the high trainability characteristics of the volunteers in relation to the strength training can explain the positive results. Since they had never performed such training, this increase in performance can be explained both by the increase of the cross-sectional area as well as by neuromuscular adaptations, such as improving intramuscular and intermuscular coordination, according to Seynnes et al. [13], who stated that morphological adaptations are preceded by neural adaptations.

It is important to emphasise that both groups performed training routines (SG = strength training and parkour, CG = parkour); only the

SG had a significant increase in performance of CMJ, suggesting that strength training was able to produce larger adaptations compared to parkour practice alone. The results of the CG indicated that the participants of this group presented stabilisation of the muscular strength performance by practising only parkour. This suggests that regular practice isolated from this modality for 24 months or more may show stabilisation in specific physical performance, which indicates the need for complementary training. Thus, strength training can be an effective option to improve strength and specific performance of parkour practitioners.

Another aspect to emphasise is the fact that the training loads between the groups were not equated. The SG had a greater training load over the course of eight weeks. This factor associated with sample trainability, which may have been the reason for the increases in CMJ performance presented by this group. The strength training adopted in this study does not represent a specific training protocol for improvement in jumping performance such as, for example, plyometric training [6, 15]. The increase in performance found was possibly due to a greater training load and not necessarily to the effects of the specific protocol used.

Although imaging and circumference measurements were not performed, the load regulations adopted in the present study (series and repetitions) are for strength training and muscle hypertrophy [10]. Most likely because of the high responsiveness to strength training, the sample may also have increased significant gains in muscle strength in response to the increased cross-sectional area of muscles during the eight weeks. This may justify the fact that parkour's isolated practice has not been able to generate the same significant increases in CMJ, such as that produced by parkour practice combined with strength training. As discussed earlier, strength training induces neural and structural adaptations. It is likely, by the configuration of the modality, that parkour's isolated practice induces neural adaptations [2, 3, 8] as well as resistance training, and possibly more specifically for parkour practice. If the structural adaptations are not significant, which is the hypothesis formulated in this study discussion, the combination of parkour practice with strength training is more efficient to improve performance in the CMJ, compared to parkour practice alone, because it involves not only neural adaptations but also possible structural adaptations in muscles.

The strength training with protocols that can generate an increase of strength and muscular hypertrophy, similar to the one adopted in the present study, also produced significant increases in the height of vertical jumps in different sport modalities, individually and collectively [15-17]. This configuration of the strength training protocol presents advantages inherent in significant increases in strength and the cross-sectional muscle area compared to plyometric training [9, 14], most commonly used to increase the height of vertical jumps [6]. However, no other studies were found that investigated the effect of strength training on the performance of parkour practitioners, which limits the discussion of the results. It is clear that other studies on this subject are needed, mainly using other protocols of strength training and tests specific to the modality.

CONCLUSIONS

Strength training increases the CMJ height of parkour practitioners. Therefore, the association of strength training with load protocol for muscular hypertrophy can increase the performance in parkour and should, therefore, be encouraged to the practitioners of this modality. However, futures studies with different training protocols and parkour-specific tests are necessary.

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Cite this article as: Rocha JA, Dias da Silva RA, Paulino Oliveira M et al. Chronic effect of strength training on vertical jump performance in parkour practitioners. Arch Budo Sci Martial Art Extreme Sport 2017; 13: 173-178