ORIGINAL PAPER

Physiotherapy Quarterly (ISSN 2544-4395)
2024, 32(4), 19–24

Effect of 12 weeks of selective cardiorespiratory endurance and plyometrics training on 800-meter rural collegiate athletes: a randomised controlled trial

DOI: https://doi.org/10.5114/pq/172316

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Abstract

Introduction. The 800-meter race is a middle-distance run where both anaerobic and aerobic energy systems contribute significantly. The purpose of the present study was to determine the effects of 12 weeks of selective plyometrics training in addition to their regular cardiorespiratory endurance training on the running performance in 800-meter rural collegiate athletes.

Methods. A total of 110 healthy volunteer rural collegiate 800-meter athletes were randomly selected based on the inclusion and exclusion criteria. Participants were randomly allocated into two equal groups (group A and group B). Group A received only conventional training, including cardiorespiratory endurance training (CON), while group B received plyometric training combined with conventional training, including cardiorespiratory endurance training (PLYO). Statistical analyses used a one-way ANOVA with post hoc testing applied between all the parameters within the groups, and an unpaired *t*-test was used to compare post-training values between the CON and PLYO groups.

Results. Group A's mean age (years), weight (kg), height (cm), BMI (kg/m^2), and pulse (beat/min) were 19.22 (1.53), 60.68 (10.47), 170.4 (6.55), 20.88 (3.48), and 83.78 (9.74), respectively, and group B's were 19.48 (1.18), 63.16 (9.31), 171.8 (5.16), 21.37 (2.80), and 86.22 (11.69), respectively.

Conclusions: The current study's findings indicate that 12 weeks of selective plyometric training has a significant impact in enhancing anaerobic power and a substantial effect on improving the 800-meter running time of rural collegiate athletes, but had no impact on VO_2 max.

Key words: 800 m running, VO_2 max, anaerobic power, F30, plyometrics

Introduction

The 800-meter race is considered a middle-distance run requiring significant contributions from the anaerobic and aerobic energy systems [1]. The 800-meter run is dependent on many physiological variables as it requires a greater intensity than marathon running but less than short-distance runs [2]. There is a paucity of research on the 800-meter run, possibly due to there being many variations in the factors affecting performances. The performance in the 800-meter race is quite different as the biomechanical and physiological factors are challenged to maintain homeostasis while running at high velocity [3]. Endurance and strength are needed to perform the 800-meter run. The strength and power are facilitated by fast twitch muscle fibres, whereas endurance is through slow twitch muscle fibres [4].

Cardiorespiratory endurance, also known as VO_2 max (maximal consumption of oxygen voluntarily), is believed to be the most important determinant of an individual's fitness [5, 6]. The VO_2 max is the ability to perform moderate- to high-intensity exercises for a prolonged period of time by an individual [7], as is required for running the 800-meter race. Cardiorespiratory endurance training can be performed by various methods such as brisk walking, jogging, running, cycling, swimming, etc. Computer-connected calibrated treadmill running, jogging, or brisk walking is also convenient and effective and can be helpful in recording VO_2 max in participants [8].

Plyometrics exercises require eccentric contractions followed by concentric contractions of muscles, which enables the muscles to have a myotatic stretch reflex during the stretch-shortening cycle, and these plyometric exercises are an important component of anaerobic exercise [9, 10]. The reactive ability of the neuromuscular system is also being improved by plyometrics exercises, helping to improve the excitability of the nervous system [11]. There are many plyometrics exercises, including standing jumps, various box drills, multiple hops and jumps, etc. [12].

Since, 800-meter running performances require aerobic and anaerobic performances, and cardiorespiratory and plyometrics training help improve VO_2 max and anaerobic power, respectively. Further, if there is any effect of plyometric training on anaerobic power that can affect performances in the 800-meter race, then there will be a broader scope for athletes, coaches, trainers, physiotherapists, managers, etc., to enhance athletic performance.

Several studies have found the effects of cardiorespiratory endurance training on many sports which require endurance, as well as studies that have seen the effect of plyometric training on many sports requiring sudden explosive or agile activity [13, 14]. Other studies have seen an effect of intermittent sprinting and plyometrics on endurance running [15], but there is a paucity of research works on the effect of these trainings on 800-meter running performances in rural collegiate athletes. Therefore, the present study will help in finding the effect of selective plyometric training sessions with car-

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Received: 05.08.2023
Accepted: 14.09.2023

Citation: Kumar N, Badwe AN. Effect of 12 weeks of selective cardiorespiratory endurance and plyometrics training on 800-meter rural collegiate athletes: a randomised controlled trial. Physiother Quart. 2024;32(4):19–24; doi: https://doi.org/10.5114/pq/172316.

diorespiratory endurance training on 800-meter rural collegiate athletes. The purpose of the present study was to determine the effect of 12 weeks of selective plyometrics training in addition to regular cardiorespiratory endurance training on 800-meter running performances in collegiate athletes.

Subjects and methods

A total of 150 voluntary participants were identified and approached for this study, in which a total of 110 healthy voluntary rural collegiate 800-meter athletes from different colleges within the Rahata Talluka of Ahmednagar district aged between 18 to 25 years and were randomly selected based on inclusion and exclusion criteria. Participants with any recent injury and any medical and/or psychological conditions which may affect their performances were excluded from this study. The minimum eligibility of participants was to qualify using PAR-Q, and they all submitted their written informed consent.

The following variables were taken: height (cm) measured by a stadiometer and weight (kg) measured by a digital weighing machine.

Maximal consumption of oxygen voluntarily/VO_2 max (Beep test) [16]: This test required running between two lines, 20 m apart, in response to recorded beeps. The test subjects stood behind one of the lines, facing the other, and began running when the tape instructed them to. The initial speed was pretty modest. The subject continued running between the two lines, turning when the recorded beeps signalled. After one minute, a sound beep indicated that the pace had to increase, and the beeps became closer together. This was repeated for each minute. If the subject does not reach the line in time for each beep, he or she must rerun to the turn line and attempt to finish the assignment in two more 'beeps'. In addition, if the line is reached before the beep, the subject must wait until the beep. If the participant failed to reach the line (within 2 m) for two consecutive segments, the test was terminated. The level and number of shuttles (20 m) attained by the athlete before they were unable to keep up with the recording were used to calculate their score. Using a mobile app, this score was converted to a VO_2 max comparable score.

Anaerobic power (RAST – Running Based Anaerobic Sprint test) [17]: Initially, each participant's body mass was assessed using identical garments to obtain data used in the RAST Test. Two lines posted on the floor marked a sprinting track of 35 m, with cones set at each end. Participants were told to do six 35-meter sprints at top speed while crossing each line. Participants were verbally encouraged to run as quickly as they could during each run to maximize effort. Participants were permitted to relax for 10 s between runs before turning around to prepare for the next sprint. Each 10-second interval between sprints was also manually timed. "Ready, 3, 2, 1, go" was the instruction for the initial sprint. A countdown from 6 to 1 and the start signal "go" sufficed for the last five sprints. Power was measured in watts (W) and computed as power = (Body Mass/*Distance2)/Time. Mean power (MP) was defined as the average power across the six sprints, while peak power (PP) was the highest estimated power and minimum power (MNP) was the lowest.

The F30 sprint test [18] measures the sprinting ability over a short distance, which is important for many sports and has been linked to performance in a variety of activities. F30 is a run performed on a straight track with cones and lines at 30 and 60 m from the starting point. The participants waited for the signal at the starting point before taking off at full speed. The best time was chosen in the study after participants completed two trials separated by 5 min.

The 800-meter running time was collected after a self-selected velocity warm-up and 5 min of rest. The participants were instructed to complete an 800-meter run in the shortest amount of time possible.

All 110 participants were divided randomly with the help of random number generation by MS Excel into two equal groups of 55 participants each (group A and group B). Group A was the control group, which received only conventional training, including cardiorespiratory endurance training, and group B received plyometric training as per the designed schedule (Table 1), with conventional training, including cardiorespiratory endurance training (PLYO) for 12 weeks. After 12 weeks of their regular group-specific training, their anaerobic power, F30 time, VO_2 max, and 800-meter running time were recorded. A total of 10 participants, 5 from each group, expressed their unavailability and requested to voluntarily withdraw during follow-up. Hence, a total of 100 participants, 50 in group A and 50 in group B, completed the intervention (Figure 1).

Table 1. Plyometric training program

Exercise	Sets	Repetitions	Total
First phase (0–6 weeks)			
bilateral horizontal jumps	2	15	30
unilateral zig-zag jumps	2	8	16
bilateral vertical jumps	2	15	30
unilateral horizontal jumps	2	6	12
depth jumps	2	10	20
Second phase (6–12 weeks)			
bilateral horizontal jumps	3	12	36
unilateral zig-zag jumps	3	6	18
bilateral vertical jumps	3	12	36
unilateral horizontal jumps	2	8	16
depth jumps	2	15	30

Interventions: selective plyometrics training

This program had two phases, each lasting 6 weeks, as shown in Table 1. Plyometrics training is performed two times a week on non-consecutive days (Tuesdays and Thursdays) under strict supervision and control. Every session began with a 10-minute warm-up that included jogging at a self-selected pace. The plyometric sessions took ~25 min and were followed by 5 min of rest [19].

Data analysis

The descriptive statistics for all outcomes measured were expressed as mean and SD. One-way ANOVA with post hoc testing was applied between all the parameters within the groups. An unpaired *t*-test was used to compare post-training values between CON and PLYO groups. The confidence interval was set at 95%. The analysis was done using IBM SPSS Statistics for Windows, Version 20.0. Armonk, NY: IBM Corp.

Results

A total of 100 rural collegiate 800-meter athletes voluntarily participated in the present study. They were randomly divided into two equal groups. Group A, the CON group, received only their regular training, which also included cardiorespiratory training. Group B, the PLYO group, received se-

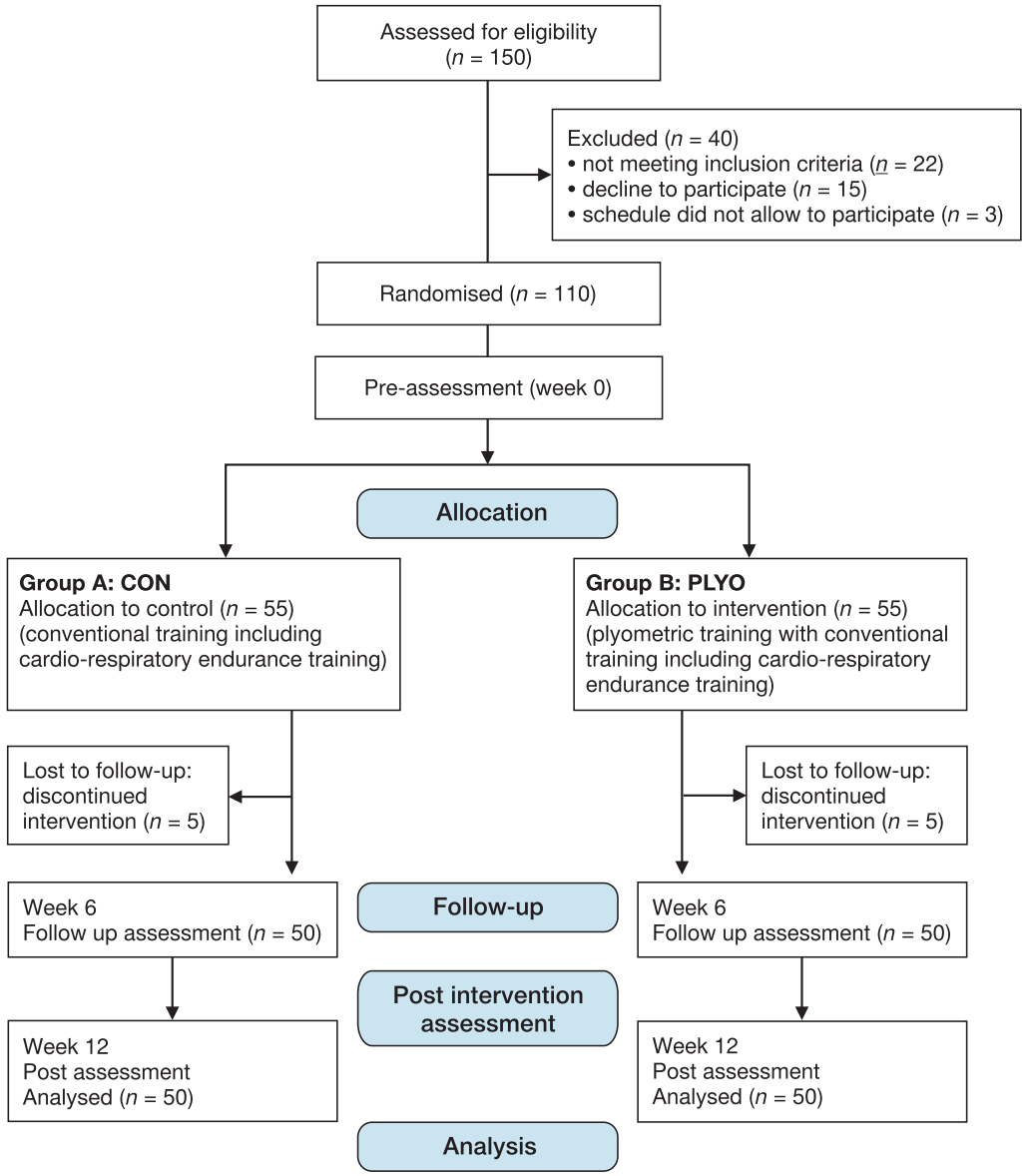

Figure 1. CONSORT diagram of flow of participants through the trial

Table 2. Descriptive data of both groups

Group	Age (years) mean ± *SD*	Weight (kg) mean ± *SD*	Height (cm) mean ± *SD*	BMI (kg/m^2) mean ± *SD*	Pulse (beat/min) mean ± *SD*
CON	19.22 ± 1.53	60.68 ± 10.47	170.4 ± 6.55	20.88 ± 3.48	83.78 ± 9.74
PLYO	19.48 ± 1.18	63.16 ± 9.31	171.8 ± 5.16	21.37 ± 2.80	86.22 ± 11.69

CON – control group, PLYO – experimental group

Table 3. Descriptive data of the variables of both groups

Group		VO_2 max (ml/kg/min) mean ± *SD*	Anaerobic power (W) mean ± *SD*	F30 time (s) mean ± *SD*	800-meter time (min/s) mean ± *SD*
CON	pre	35.39 ± 4.49	321.29 ± 106.47	5.45 ± 0.26	3.43 ± 0.20
	post 6 week	35.39 ± 3.96	321.7 ± 105.6	5.31 ± 0.23	3.38 ± 0.18
	post 12 week	35.86 ± 3.35	325.4 ± 129.9	5.22 ± 0.17	3.36 ± 0.14
PLYO	pre	36.26 ± 3.54	347.04 ± 122.42	5.44 ± 0.27	3.44 ± 0.26
	post 6 week	36.41 ± 3.57	416.84 ± 112.98	5.30 ± 0.14	3.37 ± 0.21
	post 12 week	36.56 ± 3.51	437.01 ± 109.73	5.17 ± 0.07	3.31 ± 0.17

CON – control group, PLYO – experimental group

Table 4. Comparison within groups and between groups (*p*-values)

Group	Between groups	VO_2 max (ml/kg/min)	Anaerobic power (W)	F30 time (s)	800-meter time (min/s)
CON	pre and post 6 week	0.5	0.15	0.00*	0.11
	post 6 week and post 12 week	0.10	0.42	0.00*	0.26
	pre and post 12 week	0.11	0.41	0.00*	0.03**
PLYO	pre and post 6 week	0.12	0.00*	0.00*	0.00*
	post 6 week and post 12 week	0.12	0.00*	0.00*	0.00*
	pre and post 12 week	0.00*	0.00*	0.00*	0.00*
Between groups (CON and PLYO)	pre	0.14	0.13	0.39	0.36
	post 6 week	0.10	0.00*	0.37	0.38
	post 12 week	0.15	0.00*	0.03**	0.04**

CON – control group, PLYO – experimental group
* statistically significant $p < 0.001$,** statistically significant $p < 0.05$

lective plyometric training along with their regular training. Mean age (years), weight (kg), height (cm), BMI (kg/m^2), and pulse (beat/min) of group A were 19.22 (± 1.53), 60.68 (± 10.47), 170.4 (± 6.55), 20.88 (± 3.48), and 83.78 (± 9.74), respectively, and in group B they were 19.48 (± 1.18), 63.16 (± 9.31), 171.8 (± 5.16), 21.37 (±2.80), and 86.22 (± 11.69), respectively, as shown in Table 2.

The descriptive data of all the variables of both groups are shown in Table 3.

One-way ANOVA with post hoc testing was applied between all the parameters within the groups, and an unpaired *t*-test was used to compare post-training values between the CON and PLYO groups and the findings are shown in Table 4.

Discussion

The purpose of the present study was to find the effect of 12 weeks of selective cardiorespiratory endurance and plyometrics training on 800-meter Collegiate Athletes. A total of 100 collegiate 800-meter athletes equally divided into CON and PLYO groups voluntarily participated in this study.

The BMI (kg/m^2) of the CON and PLYO group participants were 20.88 ± 3.48 and 21.37 ± 2.80, respectively, which is considered normal [20]. In a study, Sedeaud et al. [21], suggested that middle-distance running times are related to BMI. In another study, O'Connor et al. [22] found that athletes whose BMI was classified as overweight did not have as good of a time in middle-distance running.

The average VO_2 max (ml/kg/min) of group A (CON) and group B (PLYO) was 35.39 ± 4.49 and 36.26 ± 3.54, respectively, which is below the standard [23–25]. There might be many factors that need to be studied in the future. The aerobic capacity of these athletes can be improved by proper aerobic training. In a study conducted by Støren et al. [26], middle-distance running times are related to the athlete's aerobic capacity.

The difference between pre-values of VO_2 max between the CON and PLYO groups was 0.14, which was statistically insignificant. In the CON group, the difference between pre- and post-6-week values of VO_2 max was 0.5, between post-6-week and post-12-week values was 0.10, and between pre- and post-12-weeks was 0.11, which were statistically insignificant. In the PLYO group, the difference between pre- and post-6-week VO_2 max values was 0.12, and between post-6-week and post-12-week values was 0.12, which are again statistically insignificant. However, the difference between pre- and post-12-week values was 0.00, which is statistically significant. The comparison between post-6-week values of VO_2 max between the CON and PLYO groups was 0.10, and between post-12-week values was 0.15, which are again statistically insignificant. With these findings, it can be suggested that the VO_2 max of these athletes did not improve in 6 weeks with either regular exercises or selective plyometrics exercises. Since these athletes did not perform any intensive aerobic exercises, they have either done their regular exercises or plyometric exercises, it can be understood that 6 weeks of these exercises were not helpful in improving VO_2 max. Furthermore, this study found that 12 weeks of regular exercises in the CON group does not help in improving VO_2 max, whereas, 12 weeks of regular exercise with plyometric exercise in the PLYO group helps by improving the VO_2 max. The most probable reason for this could be the proper monitoring and strict supervision by researchers of all the participants in the PLYO group. It is also imperative to mention that plyometric exercises are a type of anaerobic exercise, and it has limited evidence in improving VO_2 max [27, 28].

The average anaerobic power (W) of group A (CON) and group B (PLYO) was 321.29 ± 106.47 and 347.04 ± 122.42, respectively, which is well below standard values [29, 30]. Anaerobic power can be improved with the help of a well-guided strength training program. Støren et al. [26] suggested in a study that anaerobic power is an important component of middle-distance running, and they are correlated. The difference between the pre-values of anaerobic power between the CON and PLYO groups was 0.13, which was statistically insignificant. In the CON group, the difference between pre- and post-6-week values of anaerobic power was 0.15, between post-6-week and post-12-week values was 0.42, and between pre- and post-12-week values was 0.41, which are all statistically insignificant. In the PLYO group, the difference between pre- and post-6-week values of anaerobic power was 0.00, between post-6-week and post-12-week values was 0.00, and between pre- and post-12-week values was 0.00, which were all statistically significant. The comparison between post-6-week values of anaerobic power between the CON and PLYO group was 0.00, and between post-12-week values was also 0.00, which are statistically significant. With these findings, it can be suggested that in group A (CON), where only regular exercises were done, there is no improvement in aerobic power. Whereas in group B (PLYO), where plyometric exercises were done, a significant improvement in anaerobic power was seen and hence there is a significant difference between both groups. Since plyometric exercises are a type of anaerobic exercise, the findings of the present study are in line with the findings of Assunção et al. [19], which suggested plyometric exercises help in improving anaerobic power.

The average F30 times of group A (CON) and group B (PLYO) were 5.45 ± 0.26 and 5.44 ±0.27, respectively. In a study conducted by Haugen et al. [31], it was suggested that training for shorter-distance running, particularly 30-meter and 60-meter, is effective in middle-distance running. The difference between pre-values of F30 between CON and PLYO was 0.39, which was statistically insignificant. In the CON group, the difference between pre- and post-6-week values of F30 was 0.00, between post-6-week and post-12-week values was 0.00, and between pre- and post-12-week values was also 0.00, which were all statistically significant. In the PLYO group, the difference between pre- and post-6-week values of F30 was 0.00, between post-6-week and post-12-week values was 0.00, and between pre- and post-12-week values was also 0.00, which were all statistically significant. The comparison between post-6-week values of F30 between the CON and PLYO groups was 0.37, which is statistically insignificant. Whereas, the comparison between post-12-week values of F30 between the CON and PLYO groups was 0.03, which is statistically significant. With these findings, it can be suggested that F30 times can be improved by either 6 weeks or 12 weeks of either regular exercises (CON) or selective plyometric exercises (PLYO). Further, it can also be suggested that there is a significant difference after 12 weeks between both regular exercises and regular exercises with plyometric exercises in improving F30 time.

The average 800-meter running time (min/s) of group A (CON) and group B (PLYO) was 3.43 ± 0.20 and 3.44 ± 0.26, respectively, which is well below the national and international records [32, 33]. There may be certain factors for this low-level performance which need to be further studied. The difference between pre-values of 800-meter running time between the CON and PLYO groups was 0.36, which was statistically insignificant. In the CON group, the difference between pre- and post-6-week values was 0.11, and between post-6-week and post-12-week values was 0.26, which were statistically insignificant. However, the difference between pre- and post-12-week values was 0.03, which is statistically significant. In the PLYO group, the difference between pre- and post-6-week values was 0.00, between post-6-week and post-12-week values was 0.00, and between pre- and post-12-week was also 0.00, which all are statistically significant. The comparison between post-6-week values of 800-meter running time between the CON and PLYO groups was 0.38, which is statistically insignificant. Whereas, the difference between the CON and PLYO groups post-12-weeks was 0.04, which is statistically significant. With these findings, it can be suggested that 6 weeks of regular exercises in the CON group does not help in improving 800-meter running times, whereas 12 weeks of such exercises show improvements. Further, either 6 weeks or 12 weeks of plyometrics exercises in the PLYO group have significant improvements. Further, it can also be suggested that 12 weeks of selective plyometric exercises help in improving 800-meter running times if added to regular exercises and was found effective when compared to only regular exercises. The findings of the present study are quite consistent with the findings of Blumkaitis et al. [1] and Ramirez-Campillo et al. [34], which suggested that middle-distance running can be improved by aerobic and anaerobic exercises. Since the performances of these athletes were not up to standard levels, there could be a tendency towards some illegal methods to perform better in competitions. There are many athletes of national and international repute and rural athletes who indulge in doping behaviours if not getting proper training and access to facilities. These behaviours are illegal and prohibited, and can ultimately harm athletes physically, mentally, and socially [35]. Therefore, more attention is needed to improve the fitness and performances of rural athletes. Attention should be given to improving aerobic and anaerobic performances by various exercises and by other means, for example, in a study Buzdağlı et al. [36], acute Taurine supplement significantly improved anaerobic performances. Further, focus on their 800-meter performances can be given and it should be improved.

Limitations

The study has some limitations which shall be considered while interpreting the results. The rural collegiate athletes' performances are below the national or international standards, which can affect the findings. Secondly, regular exercises in group A were unsupervised by researchers. It was only supervised by their concerned coaches or physical trainers. Third, the plyometrics training in group B was given only twice a week. Future studies should consider all these limitations to plan further.

Conclusions

The findings of the present study suggest that the VO_2 max, anaerobic power, and 800-meter running times of rural collegiate athletes are well below standard norms and need to be improved with the help of proper training and guidance. Twelve weeks of selective plyometric training was found to be significant in improving the anaerobic power of the athletes as compared to those without such training. The F30 time improved by performing 12 weeks of regular exercise or plyometrics training. Further, it can also be suggested that 12 weeks of plyometrics training has a significant role in improving 800-meter running times in rural collegiate athletes.

Ethical approval

The research related to human use has complied with all the relevant national regulations and institutional policies, has followed the tenets of the Declaration of Helsinki, and has been approved by the Institutional Ethical Committee of Pravara Institute of Medical Sciences (deemed to be University), Loni (approval No.: PIMS/PhD/290 dated 13/02/2020). This study was also registered in the Clinical Trials Registry, India (CTRI) with CTRI number CTRI/2020/02/023502.

Informed consent

Informed consent has been obtained from all individuals included in this study.

Disclosure statement

No author has any financial interest or received any financial benefit from this research.

Conflict of interest

The authors state no conflict of interest.

Funding

This research received no external funding.

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