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The effects of 20-m repeated sprint training on aerobic capacity in college volleyball players

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Summary

Study aim: The purpose of this study was to examine the effects of a repeated sprint training program in addition to volleyball training on the aerobic capacity of college volleyball players.
Materials and methods: Eighteen male volleyball players were randomly assigned to either an experimental group (n = 9, age: 21.2 ± 1.3 years) or a control (n = 9, age: 21.2 ± 1.6 years) group. Both groups followed a traditional volleyball training program three times per week for 6 weeks. The experimental group additionally performed a repeated sprint training protocol immediately before each volleyball training session. The repeated sprint training consisted of 1–3 sets of 5 × 20 m maximal sprints with 20 seconds of active recovery between sprints and 4 min of passive recovery between sets. Before and after the 6-week training period, all participants performed an incremental treadmill test to determine maximal oxygen uptake (VO_{2max}) and time to exhaustion, and the repeated sprint test (10 × 20 m with a 20-second recovery between each sprint).
Results: The experimental group showed significant improvements in VO_{2max} (+7.1 ± 4.8%; p = 0.001) and running time to exhaustion (+15.8 ± 6.8%; p = 0.004) after training. The best 20-m sprint time (−2.3 ± 2.5%; p = 0.029), mean sprint time (−5.3 ± 3.1%; p = 0.001) and fatigue index (−34.1 ± 28.2%; p = 0.012) also improved significantly in the experimental group. None of these variables changed significantly in the control group (p > 0.05).
Conclusions: The current findings indicate that the addition of a repeated sprint training program can improve both the aerobic capacity and anaerobic performance of college volleyball players.

Key words: Maximal oxygen uptake – Repeated sprint ability – Conditioning – Aerobic fitness – Speed

Introduction

In volleyball, technical and tactical skills and individual physical performance capacities are the most important factors that contribute to the success of a team in competitions [21, 28, 29]. Volleyball players are required to repeatedly produce maximal or near maximal efforts (i.e., blocking and spiking), interspersed with brief recovery intervals (low – to moderate-intensity activity), over an extended period of time (~90 minutes) [33, 37, 46]. Although anaerobic capacity is essential in volleyball, a high aerobic capacity can improve the rate of recovery during a game and the ability to endure its intensity and duration [22, 42]. Therefore, increasing a volleyball player's fitness through training is a complex process that requires an increase in both aerobic and anaerobic capacity [38, 46]. High-intensity intermittent-type exercise could be considered as an appropriate training strategy for volleyball players.

Numerous studies have shown that low-volume sprint-type interval training is a potent stimulus to induce physiological adaptations that resemble traditional high-volume endurance training [6, 17]. It was found that short (<10 s) sprint training can be effective in enhancing both aerobic and anaerobic capacities [4, 9, 10, 11, 12, 23, 30]. Repeated-sprint training is characterized by a series of short sprints (3–7 s in duration), each separated by a short recovery period (<60 s) [5]. A single bout of this form of exercise is performed mainly via anaerobic pathways, but the relative contribution of aerobic metabolism to the total

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energy provision has been shown to increase when the exercise bouts are repeated with short recovery intervals [16]. Likely, the incomplete recoveries which characterize repeated sprint training contribute to the aerobic adaptation of the muscle [1].

During a volleyball match, players perform different types of physical activities such as the various sprints, jumps, and high-intensity court movement [21]. Volleyball players require the ability to perform these physical activities characterized by repeated maximal efforts with limited recovery during the match [36, 38]. Although volleyball is not an endurance sport per se, an optimum level of aerobic capacity is crucial for the ability to maintain an elevated intensity of work to play in top-level professional leagues [26, 37, 38]. Maximal oxygen uptake (VO_{2max}) has been commonly used as a criterion of aerobic capacity [26, 43] and used in physiological monitoring of athletes [43]. Various studies have shown that repeated sprint training is an effective training strategy for improving the VO_{2max} and high-intensity intermittent exercise performance of athletes from different sports [4, 11, 12, 30]. However, to our knowledge, the effects of the addition of repeated sprint training to volleyball players' training have not been examined.

The purpose of this study was to examine the effects of a repeated 20 m sprint training program on aerobic capacity, when added to the traditional training of college volleyball players. We hypothesized that a 20 m repeated sprint training program together with regular volleyball training would improve the aerobic capacity and anaerobic performance of volleyball players compared with volleyball training alone.

Material and methods

Participants and experimental design

Eighteen male volleyball players competing in Division I of the Turkish University League volunteered to participate in the study. All of the subjects were members of the Erciyes University volleyball team. All players had trained and competed regularly in volleyball for at least 4 years. The Erciyes University Ethics Committee approved the study. All testing and training procedures were fully explained, and written informed consent was obtained for each subject. During the study, the players were not allowed to perform any additional conditioning training (e.g. strength, speed, plyometric or aerobic) that would affect the results of the study.

The study lasted a total of 8 weeks and started 2 weeks after the beginning of the preparatory training season. The experimental protocol consisted of baseline testing (pretest), a 6-week training intervention, and post-testing. Baseline testing occurred within one week prior to the start of the 6-week training period. Post-testing began 4 days after completion of the 6-week training period. After baseline testing, 18 volleyball players were randomly divided into two equal groups: the experimental and control groups (Table 1). Both groups followed a traditional volleyball training program three times per week for 6 weeks. All training sessions in both groups were conducted at the same time of day on Monday, Wednesday and Friday of each consecutive week. The experimental group additionally performed repeated sprint training prior to their normal volleyball training sessions.

Approximately 10 days prior to commencing the 6-week training protocol, subjects completed full familiarization with all testing procedures. Following the familiarization procedures, all players performed two tests with an interval of 3 days between each test. The two tests consisted of an incremental treadmill test and the repeated sprint test. Baseline and post-testing began with an incremental treadmill test and took place at the High Altitude and Sports Science Research and Implementation Center at Erciyes University. All repeated sprint testing and training sessions took place on an indoor volleyball court at the Erciyes University School of Physical Education and Sport. All tests were conducted at the same time of day for each subject so as to avoid diurnal variations in performance. Members of both groups did not perform any training during the week before or the week after the 6-week training period.

Incremental treadmill test

Maximal oxygen uptake (VO_{2max}) was determined from a progressive intensity and continuous effort treadmill protocol. All tests were performed on a motorized treadmill (h/p/Cosmos Quasar med, Nussdorf-Traunstein, Germany). Oxygen uptake (VO_2), carbon dioxide output (VCO_2) and minute ventilation (VE) were measured online using a breath-by-breath cardiopulmonary exercise testing system (Quark PFT Ergo, Cosmed Srl, Rome, Italy). Before each test, ambient conditions were measured and the gas analyzers and turbine flowmeter were

Table 1. The physical characteristics of the experimental and control groups (Mean ± SD)

	Age [years]	Body mass [kg]	Height [cm]
Experimental group	21.2 ± 1.3	71.1 ± 7.3	183.4 ± 5.4
Control group	21.2 ± 1.6	75.7 ± 8.5	184 ± 4.4

calibrated with known certified gas concentrations (16% O_2, 5% CO_2, and balance N_2) and a 3 L calibration syringe, respectively, following the manufacturer's instructions. During the incremental testing period, heart rate (HR) was monitored continuously using a wireless HR monitor (S610i, Polar, Finland) and was synchronized to ventilatory signals. Breath-by-breath VO_2 was smoothed using a five-step average filter and then reduced to 15 s stationary averages for the incremental test (Data Management Software, Cosmed, Rome, Italy) to reduce the noise so as to enhance the underlying characteristics.

To make sure the players were properly warmed up, prepared, and accustomed to the treadmill, each participant had to warm up for 6 min at their own pace. Then the players were allowed to stop and stretch for about 3 min. Following the warm-up, players started running at 7 km/h with speed increments of 1 km/h every minute until they could no longer keep pace. The players were instructed to run until voluntary exhaustion, and given strong verbal encouragement throughout the test to elicit their best performance. The VO_{2max} was defined as the highest 15 s VO_2 value reached during the incremental test. Achievement of VO_{2max} was considered as the attainment of at least two of the following criteria: 1) a plateau in VO_2 despite increasing speed, 2) a respiratory exchange ratio (VCO_2/VO_2) above 1.10, and 3) a HR (heart rate) within 10 beats per minute of age-predicted maximum HR (220 – age) [24]. The maximal oxygen uptake value was expressed as a relative value (milliliters per minute per body mass; $ml \cdot kg^{-1} min^{-1}$). Time to exhaustion was recorded as the time from the start of the run until the point of exhaustion (the time at which the subject could no longer maintain the pace of the treadmill). Maximal minute ventilation (VE_{max}) and maximal respiratory exchange ratio (RER_{max}) were expressed as the highest 15 s average value obtained during the last stage of the incremental exercise test.

Repeated sprint test

The repeated sprint test (RST) consisted of ten repetitions of 20 m all-out sprints, interspersed with 20 s of active recovery, during which the players jogged back to the starting line. Sprint times were measured for each 20 m sprint with two ports of light sensors (Newtest 2000-sprint timing system; Newtest Oy, Oulu, Finland) placed at the starting line and the finishing line, and the recovery time was controlled by a hand-held stopwatch. RST was performed after a standard warm-up procedure that included 5 min of jogging, 5 min of stretching and 5 min of specific running drills at increasing speed. After the warm-up, each player performed two preliminary 20 m maximal sprints separated by a 2 min recovery period. The fastest sprint time was used as the criterion score for the RST. After these trials, subjects rested for 5 min before the start of the RST. If the performance in the first sprint of the RST was worse than the criterion score (i.e., an increase in time greater than 2.5%), the test was immediately terminated and subjects were required to repeat the RST test with maximum effort after a 5-min rest [4]. The players stood 30 cm behind the start line to avoid premature triggering of the timing system and completed 10 × 20 m sprints with 20 s of active jogging recovery between sprints. During the 20 s active recovery period, the players were required to decelerate after passing the finish line, and to jog around a cone and return to the starting line. A cone was placed 5 m beyond the finish line, and in this way the players had a chance to decelerate their speed. Players were instructed to complete all sprints as fast as possible, and strong verbal encouragement was provided to each player during all sprints. The recovery time was controlled by a hand-held stopwatch. During the active recovery, continuous verbal feedback was provided to ensure the players had returned to the start position in time to begin the next sprint.

From the RST data, the best sprint time (the fastest 20 m sprint time), mean sprint time (mean time to complete 10 sprints) and the fatigue index (or the sprint decrement score) expressed as a percentage were selected for the analysis. The fatigue index (FI) was used as an indication of fatigue and was calculated according to Fitzsimmons et al. [20]: FI = 100 × (total sprint time ÷ ideal sprint time) – 100, where total sprint time = sum of sprint times from all sprints, and ideal sprint time = number of sprints × best sprint time.

Training program

During the six-week training period, the players in both groups continued their regular volleyball training program which consisted of three training sessions a week, with each session lasting approximately 120 minutes (comprising warm-up, main and cool-down periods). The warm-up period consisted of jogging, submaximal jumps, full-body stretching and volleyball warm-up drills, and lasted 20 minutes. Each training session ended with a 15-minute cool-down consisting of walking and stretching. Volleyball training for the development of technical and tactical skills was the same in both groups. The main part of the volleyball session included serving, passing, and setting in small groups, blocking and spiking technique, small-sided games to work on offensive and defensive strategies, and individual tactics.

The repeated sprint training was performed three times per week immediately before the volleyball training session and lasted approximately 17 to 30 minutes (including the warm-up). After the repeated sprint training, subjects rested for 5 min before the start of the volleyball training session. Details of the weekly repeated sprint training program are given in Table 2. Training volume (in terms of number of sprint repetitions) was progressively increased over 6 weeks in an attempt to avoid overtraining

Table 2. The 6 weeks of repeated sprint training program, showing the number of sets and repetitions for each session

Week	Session	Number of sets	Repetitions × distance [m]		
1	1	1	5 × 20		
	2	1	5 × 20		
	3	1	5 × 20		
2	4	2	5 × 20	3 × 20	
	5	2	5 × 20	3 × 20	
	6	2	5 × 20	3 × 20	
3	7	2	5 × 20	5 × 20	
	8	2	5 × 20	5 × 20	
	9	2	5 × 20	5 × 20	
4	10	2	5 × 20	5 × 20	
	11	2	5 × 20	5 × 20	
	12	2	5 × 20	5 × 20	
5	13	3	5 × 20	5 × 20	5 × 20
	14	3	5 × 20	5 × 20	5 × 20
	15	3	5 × 20	5 × 20	5 × 20
6	16	3	5 × 20	5 × 20	5 × 20
	17	3	5 × 20	5 × 20	5 × 20
	18	3	5 × 20	5 × 20	5 × 20

or injuries among the players. Before the training sessions, the players in the experimental group were required to complete a standardized 15 min warm-up period, involving light jogging, a series of dynamic sprint drills (high knees, heel-flicks, and walking lunges), stretching and several acceleration runs. The repeated sprint training consisted of 1–3 sets of 3–5 × 20 m maximal sprints with 20 s of active recovery between sprints and 4 min of passive recovery between sets. Each sprint represents a maximal effort with 20 seconds allowed between each sprint for the turnaround. During the active recovery period between sprints, subjects were encouraged to decelerate as soon as possible after passing the finish line and jogged back to the starting line. Slow walking and stretching was performed in the 4 min recovery periods between sets. The number of sets performed during each training session increased from one during the first week of training, to two during the second, third and fourth weeks of training, and finally three sets were performed per session during the fifth and sixth weeks of training.

Statistical analyses

Data are reported as means ± standard deviation (SD). Statistical significance was accepted at $p < 0.05$. The normality of the data was examined by assessing the Shapiro-Wilk test on all measured variables in this study for both groups; the results indicated that all measured variables followed a normal distribution. The differences in all baseline measures between experimental and control groups were evaluated by the unpaired t-test. A paired t-test was used to compare differences between paired data within groups before and after the 6-week training period. To allow a better interpretation of the results, effect sizes were also calculated using Cohen's *d* [41]. Effect sizes were interpreted as negligible ($d \geq 0.2$), small ($0.2 \leq d \leq 0.5$), medium ($0.5 \leq d \leq 0.8$) or large ($0.8 \geq d$). SPSS version 16 was used for all analyses (16, SPSS Inc. Chicago, IL).

Results

The physical characteristics of both groups are presented in Table 1. There were no significant differences ($p > 0.05$) between the two groups for age ($d = 0$), height ($d = 0.06$), or body mass ($d = 0.62$). There were no significant baseline differences between the two groups in the VO_{2max} ($d = 0.11$), time to exhaustion ($d = 0.11$), VE ($d = 0.51$), RER_{max} ($d = 0.21$), best sprint time ($d = 0.83$), mean sprint time ($d = 0.17$, $p > 0.05$) or fatigue index ($d = 1.07$, $p = 0.051$) before the training period (Table 3).

After the training period, the time to exhaustion, RER_{max} and VE during the incremental treadmill test were increased by 15.8 ± 6.8% ($d = 1.1$, $p = 0.004$), 5.6 ± 0.7% ($d = 1.86$, $p = 0.018$), and 9.9 ± 5.8% ($d = 0.99$, $p = 0.01$), respectively, in the experimental group (Table 3). Similarly, the experimental group showed a significant increase in VO_{2max} by 7.1 ± 4.8% ($d = 1.27$, $p = 0.001$) after training. The control group showed no significant change in the time

Table 3. Results of the incremental treadmill test and repeated sprint test of the experimental and control groups before (pre) and after (post) the 6 weeks training period

	Experimental group (n = 9)		Control group (n = 9)	
	Pre	Post	Pre	Post
VO_{2max} ml · $kg^{-1}min^{-1}$	50 ± 3.6	53.4 ± 1.8*	50.4 ± 4	50.6 ± 4
Time to exhaustion (min)	8.93 ± 1.3	10.27 ± 1.1#	8.80 ± 1.1	9.07 ± 1.2
RER_{max}	1.16 ± 0.04	1.23 ± 0.04§	1.17 ± 0.06	1.17 ± 0.05
VE_{max} (L/dak)	149.1 ± 19.3	165.3 ± 15.3*	158.7 ± 20.3	161.2 ± 15.5
RST best sprint time (s)	2.93 ± 0.12	2.86 ± 0.13‡	3.02 ± 0.11	2.97 ± 0.14
RST mean sprint time (s)	3.21 ± 0.14	3.03 ± 0.11*	3.23 ± 0.1	3.15 ± 0.14
RST fatigue index (%)	9.5 ± 3	6.1 ± 3&	6.9 ± 2.1	6.2 ± 2.9

Values are means ± SD; * p = 0.001, # p = 0.004, § p = 0.018, ‡ p = 0.029, & p = 0.012, significantly different from pre-training period.

to exhaustion (d = 0.25), RER_{max} (d = 0), VE (d = 0.15) or VO_{2max} (d = 0.05, p > 0.05). The repeated sprint training program caused significant improvements of the experimental group's sprint performance. In the experimental group, the best 20 m sprint time, mean sprint time and fatigue index were 2.3 ± 2.5% (d = 0.59, p = 0.029), 5.3 ± 3.1% (d = 1.52, p= 0.001) and 34.1 ± 28.2% (d = 1.2, p = 0.012), respectively, lower after, compared with before, the training period (Table 3). There were no significant changes in the best 20 m sprint time (d = 0.42), mean sprint time (d = 0.7) or fatigue index (d = 0.05, p > 0.29) for the control group.

Discussion

The results of this study showed that the repeated sprint training program led to a significant improvement in best sprint time, mean sprint time and fatigue index of the repeated sprint test, VO_{2max}, RER_{max} and time to exhaustion during the incremental treadmill test in the experimental group, whereas no change occurred in the control group. Our findings suggest that the addition of sprint interval training programs, three times per week, to normal volleyball training sessions represents an effective means of increasing aerobic capacity and anaerobic performance in college volleyball players.

VO_{2max} is regarded as the best determinant of aerobic capacity [26, 43]. The repeated sprint training significantly improved the aerobic capacity of the experimental group as evidenced by the increase in VO_{2max} (7.1%). Likewise, previous investigators have reported a 5.0–6.1% increase in VO_{2max} after 4–7 weeks of short sprint training [4, 9, 11, 12]. The longer (incremental) treadmill run time (15.8%) recorded after training demonstrates that repeated sprint training can also improve aerobic endurance. The improvements in aerobic and anaerobic performance after the repeated sprint training in the present study are consistent with the findings of previous studies using short sprint-based training [4, 9, 11, 12, 30]. For example, Dawson et al. found significant improvement in VO_{2max} of untrained young males following a training program that consisted of short (30 to 80 m) sprints performed three times per week for 6 weeks [9]. In addition, supramaximal treadmill run time, and single (40 m) and repeated (6 × 40 m) sprint performance were improved after training in their study. Bravo et al. found similar improvements with junior soccer players during the competitive season. Seven-week repeated sprint training consisting of three sets of six 40 m all-out sprints (with 20 s of rest between sprints and 4 min between sets) significantly improved VO_{2max}, football-specific endurance and repeated sprint performance [4]. Their results were confirmed by Meckel et al., who reported that a repeated sprint training program (4–6 sets of 4 × 50 m all-out sprints) improved soccer players' VO_{2max} (predicted from the 20 m shuttle run), 30 m sprint time, 4 × 10 m shuttle running time and 250 m running time during the preparation period [30]. The importance of repeated sprint training in athletes has been recently confirmed by Farzad et al. [11]. They examined the effects of 4 weeks of a short sprint-based training (6 × 35 m sprints at maximum effort with a 10-second recovery between each sprint) program on selected aerobic and anaerobic performance indices when added to the traditional training of wrestlers during the pre-season phase. After this training intervention, wrestlers showed significant improvements in VO_{2max}, time to exhaustion test, and peak and mean power output during Wingate testing. Fernandez-Fernandez et al. found that the execution of repeated sprint training (3 sets of 10 × 5-second shuttle sprints interspersed with 20 seconds of passive recovery) improved tennis players' VO_{2peak} and mean sprint time in the repeated sprint test [12]. Thus, it appears that repeated sprint training is a potentially efficient and effective means to improve aerobic and anaerobic performance capacity of athletes. However, no study to our knowledge has examined the effect of a training program based on the repetition of 20 m all-out sprints interspersed with 20 s of active recovery on aerobic capacity. This study clearly demonstrates that very short sprint (20 m) training can be used as an effective training strategy for improving the aerobic capacity of athletes.

After the repeated sprint training, RER_{max} values were higher during the incremental treadmill test, which may have been due to the longer running time to exhaustion. An RER value higher than 1.00 is related to non-metabolic CO_2 production from bicarbonate buffering of lactic acid during maximal exercise [40]. After the sprint training period, blood lactate concentrations may rise during exhaustive exercise, which may be explained by the increase of the muscle buffer capacity and glycolytic enzymes [31, 35]. In the experimental group, the higher RER_{max} recorded after training suggests that repeated sprint training may also enhance anaerobic capacity.

Improvements in aerobic fitness may be important not only for endurance performance, but also for intermittent activities [18, 42]. A higher VO_{2max} has been associated with the ability to perform more work during team-sport games and improved intermittent exercise performance [25]. This may explain the improvements in repeated sprint ability seen after repeated sprint training in the present study, which occurred in conjunction with an increase in VO_{2max}. Our results are consistent with the findings of previous studies reporting a significant increase in both VO_{2max} and repeated sprint ability after short sprint training [4, 9, 30].

The ability to recover quickly in order to perform subsequent sprints is an important fitness requirement that has been termed repeated sprint ability [3]. To develop sprint ability, athletes and coaches often employ training methods that involve brief maximal intensity sprint repetitions of varying duration interspersed with either long or short recovery periods [44]. In the present study, three repeated sprint training sessions per week over 6 weeks allowed the experimental group to significantly improve the best 20 m sprint time (2.3%) of the repeated sprint test. Repeated sprint training also improved the mean sprint time (5.3%) and reduced fatigue during the repeated sprint test (10 × 20 m), as evidenced by the 34.1% lower fatigue index after training. This improvement in mean sprint time appeared to be attributable to an improved ability to maintain sprint performance during the repeated sprint test [2]. Sprint training consisting of short maximal sprints (4 s) interspersed with brief recovery periods (20 s) has been reported to be efficient in improving performance during multiple-set repeated-sprint exercise [34]. The improvements in repeated sprint ability after the repeated sprint training in the present study are consistent with the findings of previous studies using short sprint-based training [4, 7, 9, 31]. However, the fatigue index did not change after the training in these studies [4, 7, 9, 31]. On the other hand, the best sprint time, mean sprint time and fatigue index were improved after repeated sprint training in the present study, suggesting that this type of sprint training can be considered an effective training strategy for improving athletes' sprint speed and ability to recover.

In the present study, no significant change was observed in the VO_{2max} of the control group after the training program, demonstrating that aerobic capacity cannot be increased by volleyball training alone. Furthermore, the control group did not show any significant improvements in the running time to exhaustion, 20 m sprint speed or repeated short sprint performance after the training. The current findings suggest that volleyball training alone may not suffice for the improvement of physical performance capacities of volleyball players. Skill-based volleyball training has been shown to have a minimal effect on the physical fitness of volleyball players [13, 14]. Gabbett et al. found that 8 weeks of skill-based volleyball training significantly improved the skill levels of talent-identified volleyball players, without significantly altering VO_{2max} (predicted from the multistage fitness test) [14]. It is likely that the characteristics of the volleyball training (i.e., volume and intensity) stimulus employed by the control group of this study were inadequate to induce significant central and/or peripheral adaptations for improvements in VO_{2max} [14]. The sport of volleyball is demanding and requires speed, agility, upper and lower body muscular power and high VO_{2max} [14, 15, 32]. Therefore, physical conditioning training along with skill-based volleyball training is necessary for the improvement of physical performance capacities in volleyball players.

Although the literature has shown that the VO_{2max} is a key component of physical fitness for a volleyball player [14, 15, 26, 32, 37, 38, 46], few studies have examined the effect of volleyball and physical conditioning training on the VO_{2max} [14, 15, 19, 21, 27, 32]. However, most of this research has used conditioning programs that include both sprint and aerobic endurance training, to improve speed and aerobic fitness of volleyball players [8, 19, 27, 39]. In modern volleyball, the high frequency of matches during the competitive season limits the number of training sessions devoted to physical fitness development [21, 29]. Therefore, it would be valuable to identify a single training method that could improve both the aerobic and anaerobic performance capacity. Numerous studies have shown that both aerobic and anaerobic performance capacity can be increased during the pre-season or in-season by a program of sprint training alone in wrestlers [11], soccer players [4, 30] and tennis players [12]. However, to our knowledge, there is no previous study examining the effect of repeated sprint training in volleyball players. Our results show that VO_{2max} can be improved using a repeated sprint training program alone, with no involvement of aerobic endurance training. Hence, our data represent a rather novel finding that could be of considerable importance for improving training methods aimed at improving both the speed and aerobic fitness of volleyball players. Coaches may use the results of this study to plan specific conditioning programs for volleyball players.

Conclusions

In conclusion, the results of the present study indicated that a 6-week sprint interval training program can improve the aerobic capacity of volleyball players when added to the traditional training of college volleyball players. The experimental group showed significant improvements in the VO_{2max}, running time to exhaustion and repeated short sprint performance, whereas the control group showed no significant improvement, which could be explained by the extra 20 m repeated sprint training. These findings suggest that repeated sprint training can be an effective training strategy for inducing aerobic and anaerobic adaptations. As a result, 20 m repeated sprint training can be easily incorporated into the training program of volleyball players desiring to increase both aerobic capacity and anaerobic performance. It can be suggested that this training method may be the preferred model for volleyball coaches and players to improve aerobic capacity and anaerobic performance.

Conflict of interest: Authors state no conflict of interest.

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