Journal of Health and Physical Literacy

The Cardiovascular Fitness Effect of Zone 2 Training Among High School Soccer Athletes

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Article Type: Original Research

ABSTRACT

Purpose: The purpose of this study was to observe the cardiovascular training effect of a 5-week Zone 2 training program among high school soccer players. **Methods:** Prior to the start of the competitive high school soccer season, the researchers used the Progressive Aerobic Cardiovascular Endurance Run (PACER) test to assess aerobic capacity. Participants (N – 12) met three days per week to participate in a Zone 2 training program that consisted of jogging/running at specific durations for five weeks. At the conclusion of the five-week training, the researchers again tested aerobic capacity using the PACER test. **Results:** The results indicated a statistically significant change in aerobic capacity among the participants. **Conclusion:** The researchers conclude that, as a method of preseason training among the population studied, Zone 2 exercise appears to provide a very cost effective, easy-to-employ method of training that significantly improves aerobic performance, carries minimal risk of injury, and delays the onset of physical and mental fatigue.

Keywords: Aerobic capacity, PACER, Coaching

1. INTRODUCTION

Preseason training for high school soccer players is an effort to develop high levels of fitness among athletes prior to the start of the rigorous competitive season. The preseason training period for spring sports at public high schools in the southeastern United States begins on the first day of school in January and ends on the first official practice date as determined by a governing sports association. In the quest to enhance athletic performance, soccer players and coaches continually seek effective training strategies to optimize endurance, speed, and overall fitness while minimizing injury risks during the five weeks of preseason. One effective strategy is the use of periodization. A well-designed periodization program manipulates training intensities tailored to ensure an appropriate balance between training stress and recovery (Borges, et al., 2019). One aspect of the periodization program is pre-season conditioning and establishing an aerobic base (Bompa, 2015).

Among the various training intensities, Zone 2 (lower to intermediate intensity) training has emerged as a pivotal component in developing aerobic capacity and sustaining peak performance (Attia, 2023; Borges, et al., 2019; Seiler & Tonnessen, 2009). Zone 2 training, characterized by exercise intensity that elevates the heart rate to approximately 60-70% of its maximum, is known for its role in improving the body's ability to utilize fat as a primary energy source and enhancing cardiovascular efficiency (Attia, 2023; San-Millan & Brooks, 2018). Data suggests that elite adolescent soccer players spend a majority of their training sessions in the low-intensity zones (Borges, et al., 2019). Despite its growing popularity, there remains a limited body of research specifically addressing the benefits of Zone 2 training for adolescent athletes in soccer — a sport demanding both aerobic endurance and high-intensity bursts (Borges et al., 2019).

It is well established that soccer performance is highly dependent on aerobic capacity (Bangsboro et al., 2007; Helgerund et al., 2001; Stolen et al., 2005). Helgerund et al. (2001) found that heightened levels of maximal oxygen uptake, or $V0_2$max, led to improvements in total distance covered and total number of sprints during a match. Stolen et al. (2005) found that soccer places an extreme demand on aerobic metabolism. The researchers stated that, during a 90-minute match, competitive soccer players' average work intensity is near their anaerobic thresholds, or "the highest exercise intensity where the production and removal of lactate is equal" and leads to fatigue (Stolen, et al., 2005, p. 503). However, the establishment of an aerobic base through low-intensity training helps remove the lactate quicker from the working muscles and aids in a quicker recovery (Attia, 2023; Galpin, 2024; Stolen, et al., 2005). Performing training loads at low-intensity also helps produce more mitochondria (Attia, 2023; San-Millan & Brooks, 2018). This is of great importance because "Mitochondria are intracellular organelles that produce much of our energy and burn both glucose and fat" (Attia, 2023, p. 237). Although glucose can be metabolized in multiple ways, fatty acids are metabolized strictly through the mitochondria (Attia, 2023). The key to fat metabolism is that fatty acids are a more abundant and efficient fuel source (Attia, 2023). Therefore, the more mitochondria a player has, the more energy he or she can produce. The more energy an athlete can produce, the better the player can perform.

One of the biggest questions concerning Zone 2 training is how to calculate it. The gold standard method of calculating a person's Zone 2 is through testing blood lactate. When individuals exercise in Zone 2, they are utilizing their type 1 or "slow twitch" muscle fibers (Attia, 2023). These intricate fibers are heavily populated with mitochondria which is most suitable for the slow-paced, long duration type of exercise. However, when a person picks up the intensity, the body will start to incorporate more of the type 2 or "fast twitch" muscle fibers. These fibers are less efficient, and they generate more lactate in the process (Attia, 2023). Once a person's lactate gets too high (greater than 2.4 millimoles) a person is no longer in Zone 2 but in Zone 3. Therefore, the goal is to keep your lactate levels constant, somewhere between 1.7 and 2.0 millimoles (Attia, 2023). A downside to calculating blood lactate is that a portable lactate meter is required to obtain a blood sample. Portable lactate meters can be expensive and are considered minimally invasive to some individuals considering it requires breaking of the skin with a finger or ear prick. Another reliable method of measuring Zone 2 is by a person's maximum heart rate. This is not obtained as an estimate but as a true measure of a person's maximum heart rate obtained using a heart rate monitor. An individual would need to acquire a heart rate monitor to wear around their chest and pair it with a wristwatch, or they could purchase a wristwatch with heart rate capabilities. Obtaining a reliable chest strap and wristwatch or wristwatch only could cost an individual somewhere in the hundreds of dollars. Once obtaining their maximum heart rate from a bout of exercise, the individual could obtain their Zone 2 training zone by corresponding their maximum heart rate to approximately 70 and 85 percent of their maximum heart rate, depending on their fitness level (Attia, 2023). Attia (2023) stated that, "this number is such a big range that he suggests using the talk-test" (p. 240-241). The "talk-test" will be explained further in the methodology section below.

The authors of this study acknowledge the popular training modality of high intensity interval training (HIIT), and do not seek to argue its many benefits. Soccer requires repetitive sprints followed by brief periods of recovery as well as quick changes in direction, jumping, bursts of speed, kicking, heading, and tackling. There is little debate regarding the importance of the ability to perform explosive movements to achieve competitive success. In-season training, which emphasizes developing technical skills and improving tactical decisions, leaves little time for fitness work. Short bouts of high intensity exercises are therefore very time-effective during the regular soccer season, and its many training effects have been well studied. Dupont et al. (2004) found that in-season, HIIT improved maximal aerobic speed and decreased 40-meter sprint times among professional male soccer players, indicating improved anerobic performance. HIIT is an effective way to improve maximal oxygen uptake, aerobic performance, and the ability to repeatedly perform sprints (Clemente et al., 2020). However, soccer coaches need to be cautious of the injury risk that may be correlated to exercising at high intensity. Rynecki et al. (2019) found that as the trend of HIIT increased, so did the incidence of injury, particularly injuries to the lower extremities. Owen et al. (2015) found correlations between high intensity training volume and injury incidence among elite male soccer players, and that players who spent more time in very high intensity training were more likely to encounter an injury during a match. These researchers concluded that the number of match injuries can be significantly reduced if coaches and athletes focus more heavily upon the training intensity and volume needed to safely reduce fatigue or overuse injuries (Owen et al., 2015).

Therefore, the purpose of this study was to examine the training effect of Zone 2 exercise among soccer players in the preseason, so that coaches and athletes may consider its use as a means of improving athletic performance with reduced injury risk prior to the start of in-season soccer training. By examining the effects of Zone 2 training on this unique population, the authors of this study sought to provide valuable insights into its potential benefits for high school soccer players. We considered how incorporating this training during preseason can influence aerobic endurance and thus prepare athletes for in-season training and competition. We evaluated the most cost-effective method used to ensure that athletes stay within the recommended training zone. Understanding these impacts will not only contribute to optimizing training regimens but also offer practical, low-cost training protocols for coaches and athletes striving to achieve peak performance while minimizing the risk of injury before and during competitive seasons.

The investigators sought to bridge the gap between theoretical knowledge and practical application, offering a comprehensive analysis of Zone 2 training's effectiveness in enhancing the athletic capabilities of young soccer players. Through rigorous assessment and data analysis, the research team aims to provide a clearer understanding of how Zone 2 aerobic training can contribute to the development of soccer players at the high school level.

2. METHODS

The research protocol was approved by the host University Institutional Review Board. The principal of the participating high school provided a letter of authorization. The researchers used preexisting data collected during the winter and spring of 2023 at a rural high school in the southeastern United States. Prior to the start of the competitive soccer season in the spring of 2023, the coaching staff, as part of normal practice procedures, required all soccer players on the boys' high school team to complete the Progressive Aerobic Cardiovascular Endurance Run (PACER) test to assess aerobic capacity. The PACER is the most common test of aerobic capacity among K-12 students, and there is strong evidence of its validity and reliability. Boreham et al. (1990) and Liu et al. (1992) found validation coefficients of $r = 0.87$ and $r = 0.72$, respectively. Test-retest reliability coefficients for the PACER have ranged from $r = 0.78$ to $r = 0.93$ (Artero, 2011).

The PACER test is a multi-stage shuttle run test that was created by Leger and Lambert in 1982 (Leger, 1982). It is designed to measure aerobic capacity, which is characterized by endurance, performance, and fitness. The objective of the PACER Test is to run as long as possible while keeping a specified pace. The PACER Test is scored based upon the number of laps completed before failure and the age of the participant. There were no assignments to groups for the test.

Data were collected from the PACER Test (pretest), and each student-athlete's score was recorded with paper and pencil and transferred into an Excel spreadsheet. After the pretest was completed, the student-athletes began their 5-week Zone 2 training.

The Zone 2 program required the student athletes to run together for a frequency of 3 days per week, for durations progressing from 30 to 60 minutes, and at a steady state within the target intensity for a total of 5 weeks. Participants ran for a duration of 30 minutes the first week, 45 minutes the second and third weeks, and 60 minutes the fourth and fifth weeks. Training primarily occurred at a park adjacent to the high school campus. The park consisted of an asphalt surface that was mostly flat with occasional, mild inclines and declines. The track surrounded an approximately 10-acre lake and therefore provided the coaching staff with the ability to visually monitor athletes. Severe weather forced the team to run on an indoor track on two separate training dates during the 5-week period. Walking was not permitted. To estimate intensity and thus stay within Zone 2, participants were directed to use the "talk test".

The "talk test" allows participants a reliable method of estimating exercise intensity while engaged in aerobic activity (Attia, 2023; De Lucca, 2021; Quinn, 2011). Zanettini et al. (2013) postulated that the "talk-test" had a high intraclass correlation coefficient for heart rate and rate of perceived exertion (RPE). Several authors have concluded that the "talk-test" is both valid and reliable, measuring a vast majority of physical parameters (Anderson, et al., 2016; Grace et al., 2016; Reed & Pipe, 2014). The talk test is conducted as follows: while performing physical activity at steady state, the participants attempt a conversation. If speaking is easy, the runner is going too slow and is not in Zone 2. If the participant is able to converse, but doing so requires some effort and is therefore somewhat uncomfortable, the participant is training in Zone 2. If the participant is breathing so heavily that a steady conversation is unattainable, then Zone 2 has been surpassed, and the runner should slow the pace. Attia (2023) describes it by stating that if the participant is having a conversation on a cellular phone, the person at the other end of the call should be able to tell that the participant is exercising.

At the completion of the 5-week Zone 2 training program, the student-athletes were given the PACER Test (posttest) and scores were recorded by paper and pencil and transferred into the same Excel spreadsheet as the pretest scores. A total of 12 (N = 12) male student-athletes completed both the pre- and posttests.

2.1 Participants

A total of 12 male, high school student-athletes took part in this study. Their ages ranged from 14 to 19 years, with a mean age of 16.3 years (*SD* = 1.5 years). Their body weights ranged from 115 to 185 pounds, with a mean weight of 150 pounds (*SD* = 21 lbs.). Their heights ranged from 5′6″ to 6′2″, with a mean height of 6′0″ (*SD* = 2.6 inches). Table 1 provides a summary of participant demographics. Two of the participants reported having played for a competitive soccer club during the fall, while the remaining 10 did not participate in organized athletic activities prior to the spring high school soccer season. Only data collected from those participants who completed the pre- and posttests and all training sessions between them were included in this study.

Table 1

Participant Demographics

Descriptors	Range	Mean	*SD*

Age	14–19 years	16.82	1.5 years
Body Weight	115–185 lbs.	150 lbs.	21 lbs.
Height	5′6″–6′2″	6′0″	2.6″

3. RESULTS

Data were analyzed using the IBM SPSS® Statistics (IBM Corp., 2022) software package. A paired-samples *t*-test was used to determine whether there was a statistically significant mean difference between the number of PACER laps completed during the pretest trial—prior to the participants beginning in the Zone 2 training program—and the number of PACER laps completed in the posttest trial that followed the 5-week, Zone 2 training program. There were no outliers in the data, as assessed by inspection of a boxplot. The difference in scores for the pretest and posttest PACER laps were normally distributed, as assessed by Shapiro-Wilk's test ($p = .741$). Table 2 provides information about the pretest and posttest descriptive statistics as well as the results of the paired-samples *t*-test analysis.

Table 2

Pretest and Posttest Difference and Paired-Samples t-test Analysis

	n	*SD*	*M*	Mean Difference	95% C.I. of the Difference Lower Upper	*t*	*p*	Cohen's *d*
Pretest	12	16.82	45.00	28.25	20.88	8.44	< .001	2.44
Posttest	12	14.58	73.25		35.62			

Results showed that participants ran more PACER laps in the posttest trial ($M = 73.25$, $SD = 14.58$) as opposed to the pretest trial ($M = 45.00$, $SD = 16.82$), which represented a mean increase of 28.25 laps, 95% CI [20.88, 35.62]. This difference reflected a 62.8% increase in the number of PACER laps completed in the posttest trial compared to those completed in the pretest trial. The increase in PACER laps was found to be statistically significant, $t(11) = 8.44$, $p < .001$, $d = 2.44$. The effect size, measured by Cohen's *d* ($d = 2.44$), indicated a large effect (Cohen, 1988). Analysis of the results provided justification to reject the null hypothesis in favor of the alternate hypothesis that Zone 2 training has a positive impact on cardiovascular fitness of high school soccer athletes.

A post hoc power analysis (Cohen, 1988) was conducted to assess the likelihood of committing a Type II error. The post hoc power analysis was performed using the G*Power computer software (Faul et al, 2007; Faul et al., 2024). Using the reported Cohen's d of 2.44, an alpha level of .05, and the study's sample size of 12, the paired samples t test has high statistical power ($1 - \beta = 1.00$). This indicates a high probability of correctly detecting a true difference between the paired groups for the results presented, and a low probability ($\beta = .00$) of committing a Type II error.

Pretest results indicated that participants entered preseason training in poor aerobic condition. The Cooper Institute reports that the minimum number of 20-meter PACER laps needed for a 16-year-old male (the average age of participants) to achieve the Healthy Fitness Zone for a health-enhancing level of fitness is 61 laps (The Cooper Institute, 2017). The average number of laps (45) recorded during the pretest fell 16 laps below the cutoff score for a healthy level of cardiovascular fitness.

Posttest results indicated that participants finished preseason training in healthy cardiovascular condition. Posttest results indicated that after 5 weeks of Zone 2 training, the mean score for participants (73.25) exceeded the minimum number of laps necessary for a 16-year-old male to achieve a health-enhancing level of cardiovascular fitness by 12.25 laps.

4. DISCUSSION

Considering the athletes did not incorporate other training strategies like interval training or tempo runs during their initial training program and the length of the study was too short to incorporate growth and maturational improvements, the specific training method specified in this study (Zone 2 Training) appeared to be effective on increasing aerobic capacity. Enhanced aerobic capacity could lead to increased mitochondrial function and stamina (Attia, 2023; San-Millan & Brooks, 2018), which would lead to better physical and technical performance on the soccer field (Dambroz & Clemente, 2022). In a systematic review analyzing soccer performance and fatigue, Dambroz and Clemente (2022) found that physical fatigue had negative effects upon technical performance, specifically, the pass, dribble, and kick. They also found that fatigue degraded sprint capacity and distances covered at high velocity.

The onset of fatigue not only degrades technical and physical performance; it also increases the likelihood of injuries. Therefore, may reduce injury risk among soccer players (Greig & McNaughton, 2014; Greig & Siegler, 2009). Match-play related fatigue degrades dynamic balance performance, which is crucial in supporting soccer-related movements such as kicking. The reduction of dynamic balance increases through the duration of a match as stamina decreases. This puts players at a greater risk of ankle-sprain injury (Grieg & McNaughton, 2014). Match-related fatigue causes a decrease in hamstring strength as well, which also leads to a greater risk of injuries, especially during explosive movements (Grieg & Siedler, 2009).

The aerobic energy delivery system is heavily relied upon to meet the physical demands of playing soccer (Bangsbo et al., 2007; Helgerund et al., 2001). The idea of using low- to moderate-intensity aerobic exercise to train soccer players is certainly not a new development in sport performance. After publishing his book "Aerobics" in 1968, Dr. Kenneth Cooper was hired to train the Brazilian National Team for the 1970 World Cup. Although ridiculed by the public for jogging to prepare for a game of sprints, Cooper became famous in Brazil after the national team clinched its third World Cup victory. To this day, jogging is translated at "Coopering' in Portuguese (Stanforth & Overdam, 2021). Players with higher levels of aerobic fitness can delay the onset of fatigue and thus play better technically, sprint farther and more often, and lower the likelihood of injury.

Our data suggests that the length of the preseason training period is sufficient for developing significant changes in cardiovascular endurance among the population studied. The training effects as measured among the participants of this study are similar to those found in the existing literature regarding cardiovascular improvements following low-intensity aerobic exercise performed over a series of weeks. Mendes et al. (2013) found that six weeks of low-intensity aerobic training improved $V0_2$ max among untrained males. Hwang et al. (2022) found that training at a low intensity for an hour, three days per week for nine weeks significantly enhanced energy recovery and endurance among male soccer players.

This study explored the cardiovascular training effect of a 5-week Zone 2 training program among high school soccer players. Although the results indicated a statistically significant change in aerobic capacity among the participants, there were delimitations and limitations to the study. Delimitations include the small sample size of 12 participants along with the limited age group and using only male participants, which could limit generalizability. Furthermore, the lack of a control group could also limit the strength of conclusions drawn. A limitation to this study is the reliability of the participants' ability to identify when they were in Zone 2 via the talk test. In addition, although the participants did not indicate they participated in other training or sports during the data collection period, it cannot be ruled out and therefore could have impacted the posttest results. Also, although the PACER is widely used and considered to be an appropriate field-based assessment, the test has its limitations. These limitations may have influenced the results of this study, and they may include noise distractions, weather conditions, a lack of motivation due to students having to perform the test to exhaustion, the difficulty in monitoring multiple participants, and that the test provides only an estimate. Participant effort is a limitation as well, and it should be noted that the test administrators observed a more positive attitude among participants during the posttest, as they appeared eager to witness the effect of their training.

The authors chose to use the "talk test" as the method of regulating participant effort. We acknowledge that fact that there are better ways of keeping participants engaged in the correct intensity of Zone 2. Lactate monitoring would be an ideal choice, and other options include heart rate monitors or the use of smartwatches. The "talk test" has limitations in that it is very subjective, affected by fitness levels, and medical conditions such as asthma or anxiety would influence "talk test" efficacy. However, we chose to use this test as it is easy to apply in the field and is applicable to low-budget athletic programs such as the one involved in this study.

The authors of this study found a gap in the literature regarding the use of Zone 2 training to improve soccer performance, which leaves opportunities for future research. Replicating this study among female high school soccer players would be of interest. Research is also needed to perhaps examine the effects of a preseason training program that includes the use of Zone 2 training for four to five weeks to establish an aerobic base before adding a series of HIIT or sprinting sessions. Researchers could also consider studying the effects of adding calisthenic training sessions between days of Zone 2 training sessions over a period of five weeks to further develop an efficient preseason program that is safe and cost-effective for lower budget sports programs such as the one used in this study.

5. CONCLUSIONS

This study suggests that aerobic capacity improved during the preseason by a specific training program that was based upon low to moderate intensity exercise and monitored by the "talk test." These results may be of interest to coaches who seek to safely improve the cardiovascular conditioning of soccer players without the cost of expensive equipment in programs with limited budgets, such as those in rural areas. Using the talk test may provide a practical field-based alternative to keep soccer players in the correct training zone, and therefore the costs of this Zone 2 training protocol are minimized and make this preseason training method accessible. Coaches and athletes who wish to build a strong aerobic base in the preseason may choose to consider Zone 2 training as a low-risk method to prepare for the physical demands of HIIT training, small-sided games, technical work, and indeed the full matches that follow during the regular soccer season.

6. ACKNOWLEDGEMENTS (all sections are mandatory)

6.1 Disclosure of Funding Sources

None

6.2 Conflict of Interest (de-identify in blinded manuscript)

The authors declare no conflicts of interest.

6.3 Contribution of Authors (exclude in blinded manuscript)

DM: study design, data collection, manuscript preparation, manuscript editing
MBP: manuscript preparation, manuscript editing
DP: data analysis, manuscript preparation, manuscript editing
BS: manuscript preparation, manuscript editing

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