

ORIGINAL RESEARCH

TIME IN 85-100% HEART RATE ZONE INCREASES LEAN BODY MASS AND VO_{2MAX} IN NCAA DIVISION I SOCCER PLAYERS

R. Ann Cook¹, Bryce Hastings², and Jinger S. Gottschall¹

¹ Department of Kinesiology, The Pennsylvania State University, Pennsylvania, USA

² Les Mills International, Auckland New Zealand

Corresponding author: R. Ann Cook

The Pennsylvania State University, Department of Kinesiology,
259 Recreation Hall, University Park, PA 16802,

Tel: +1 814-777-4396, Fax: +1 814-865-1746, Email: arc14@psu.edu

ABSTRACT

Introduction: Due to the growth and interest of women's soccer in the past 20 years, multiple scientific studies have focused on how to enhance performance. Training status, defined as lean body mass and VO_{2max} , is correlated to performance during games; specifically ground covered, number of sprints, and number of touches on the ball. Therefore, improving the training status of an athlete is a critical component of any soccer regimen. The purpose of the current study was to evaluate if a novel form of high intensity interval training (HIIT) could significantly improve training status during the 6-week offseason of an elite women's soccer team. We hypothesised that time spent in the 85-100% heart rate zone would correlate with improvements in training status; specifically lean body mass and VO_{2max} .

Methods: Eighteen NCAA Division I women soccer players replaced their 8 hours per week of traditional training with a unique 5 hour per week training intervention comprised of 2 hours of soccer specific training, 2 hours of strength training, and 1 hour of the LES MILLS GRIT™ series, a HIIT protocol that involves explosive plyometric and dynamic strength exercises. At the beginning and end of the 6-week intervention, lean mass was evaluated with a Bod Pod™ body composition test and VO_{2max} was estimated from a 2.4 km run.

Results: Both lean body mass ($r = 0.63$ and $p = 0.01$) and VO_{2max} ($r = 0.51$ and $p = 0.05$) were positively correlated to time spent in the 85-100% heart rate zone.

Conclusion: These data suggest that HIIT can be an effective protocol even in a well-trained college athlete cohort and may maximise competition performance and minimise training time.

Keywords: high-intensity interval training, exercise, soccer performance, LES MILLS GRIT

INTRODUCTION

For the past 20 years, women's soccer was the sport with the second largest collegiate population and greatest net gain in sponsorship across the United States¹. Due to this growth and interest, multiple scientific studies focused on game intensity, injury prevention as well as rehabilitation, and of course, performance. These data demonstrate that training status, defined as lean body mass and VO_{2max} , is correlated to performance during games^{2,3,4,5}. Therefore, improving a player's training status is an important component of any soccer regimen. Recent evidence suggests that training at intensities between 80-100% heart rate max, is most effective in improving lean body mass and VO_{2max} ^{5,6,7} and also mimics the intensity during a game⁸. For example, Gormley, et al (2008) found that 5-minute intervals at 75-95% of $VO_{2reserve}$ improved maximal oxygen consumption by 20.6% in six weeks for untrained participants. This kind of high-intensity interval training (HIIT) is defined as repeated bouts of short duration exercise completed at a heart rate greater than anaerobic threshold⁹. These bouts of intensity can be as short as 8 seconds or as long as 5 minutes, followed by an active partial recovery. To sum, HIIT is an effective way to reduce body fat^{3,10,11} and improve VO_{2max} ^{7,10} in a time-efficient manner^{6,12}.

High intensity interval training (HIIT) is typically performed while running or cycling, but has also been adapted to soccer-specific protocols^{13,14}. The LES MILLS GRIT™ series is a unique 30-minute HIIT program that incorporates explosive plyometric training and dynamic strength exercises. In the current study, the traditional offseason conditioning of an elite NCAA Division I women's soccer team was replaced with two 30-minute sessions of LES MILLS GRIT™ each week. This substitution minimised the amount of running the athletes typically completed, but did not sacrifice quality minutes in the highest heart rate zones. The purpose of the study was to evaluate if this novel type of HIIT training could significantly improve training status during the 6-week offseason of the women's soccer team, an already well-trained population. We hypothesised that time spent in the

85-100% heart rate zones would correlate with improvements in training status – specifically lean body mass and VO_{2max} .

METHODS

Experimental Approach to the Problem

To assess training status before and after the HIIT protocol, participants completed a Bod Pod™ test for body composition and ran 2.4 km for VO_{2max} estimation. During all of the exercise sessions, the participants wore a Polar TEAM2 heart rate monitor. At the end of the study, the amount of time in the 85-100% heart rate zone were correlated with changes in lean body mass and VO_{2max} .

Participants

Eighteen female NCAA Division I soccer players (age 19.1 years \pm 1.1; height 167.5 cm \pm 6.4; mean, \pm standard deviation) participated in the study. They received a detailed explanation of the study including any risks involved and voluntarily participated after signing a written consent form. All experimental procedures were approved by the Institutional Review Board at The Pennsylvania State University.

Procedures

The pre- and post-study testing occurred during week 0 and week 7. Each participant set up an appointment and completed a Bod Pod™ body composition test during the testing weeks. Before the appointment, each participant was instructed to abstain from food as well as exercise for 2 hours preceding and wore single-layer compression shorts, a non-padded sports bra, and a swim cap. In addition, on the first day of each testing week, the participants all completed a 2.4 km test at an indoor track. Upon arriving at the indoor track on the testing day, each participant was randomly assigned one of two groups and completed a running warm-up with her group. The participant's time in the 2.4 km run was then utilised to predict VO_{2max} using an equation adapted from Fahey, et al (2001).

The training protocol included strength training

with Les Mills BODYPUMP™ from releases 79-84 on Mondays and Fridays for 60 minutes each day, intensity training with LES MILLS GRIT™ from releases 1-3 on Tuesdays and Thursdays for 30 minutes each day and traditional soccer training on Mondays for 30 minutes and Wednesdays for 90 minutes. The BODYPUMP™ class is comprised of 9 tracks each approximately 5 minutes with a focus on major muscles groups (warm-up, squats, chest, back, triceps, biceps, lunges, shoulders, core). The LES MILLS GRIT™ series is typically comprised of 5-6 tracks with a focus on various performance variables (warm-up, agility, upper and lower body conditioning, plyometric speed intervals, core). The classes were led by an instructor with more than 10 years of experience in the Les Mills programs and who aided in the original testing of the high intensity program.

Statistical Analysis

Using historic heart rate data on each participant from her preseason testing, conducted 4 months earlier, an observed maximum heart rate was manually entered for each athlete into the Polar TEAM2 system from a maximal run test. For this study, the Polar system's default settings were used, which sets the training zones for the following ranges: 50-59%, 60-69%, 70-84%, 85-89%, and 90-100%. The Polar system, using this information and maximum heart rate data on each participant, then automatically calculates minutes in each training zone. To evaluate if there was a significant difference between the pre- and post-testing measures, we performed a paired t-test and defined significance as $p < 0.05$. In order to determine if time spent in the 85-100% heart rate zones was correlated to training status, we calculated the

Pearson correlation coefficient using SPSS. To add, we utilised the following definitions to determine the strength of the relationships between variables; 0.01-0.19 = negligible, 0.20-0.29 = weak, 0.30-0.39 = moderate, 0.40-0.69 = strong.

RESULTS

All 18 participants completed at least 95% of all training sessions through the 6-week intervention. First, with respect to body composition, body fat percentage decreased 2.5% ($p < 0.05$) while the participants' body weight increased slightly (1.0% gain) with a mean lean body mass gain of about 1.0 kg (2.2 lbs) throughout the study ($p < 0.05$). Second, with respect to VO_{2max} , mean 2.4 km time decreased by 2.6% ($p < 0.05$).

DISCUSSION

As hypothesised, time spent in the 85-100% heart rate zones led to improvements in lean body mass and VO_{2max} . Eleven of the eighteen participants improved body composition with increased lean body mass while all the participants increased VO_{2max} . These findings support past research that have demonstrated that HIIT decreases body fat and increases VO_{2max} ^{3,7,10,11}. The previous studies focused on both healthy, relatively untrained participants^{7,11} as well as highly trained male athletes^{3,10}. To our knowledge, this protocol was the first to use a highly trained female athlete population and the first to pair such a population with a novel type of HIIT. One reason for the significant changes in performance may be the specific focus of the LES MILL GRIT™ series tracks. Although each release contains varying

Table 1. Parameters of body mass, body fat, lean body mass, 2.4 km time, and estimated VO_{2max} before and after the training intervention. (mean, \pm standard deviation).

	Body Mass (kg)	Body Fat (%)	Lean Body Mass (kg)	2.4 km Time (min)	VO_{2max} (ml/kg/min)
Pre-test	62.76 (± 5.38)	21.09 (± 6.68)	48.34 (± 4.62)	10.75 (± 0.74)	49.23 (± 2.98)
Post-test	61.95 (± 4.74)	18.59 (± 6.41)	49.15 (± 4.77)	10.47 (± 0.81)	49.29 (± 3.77)

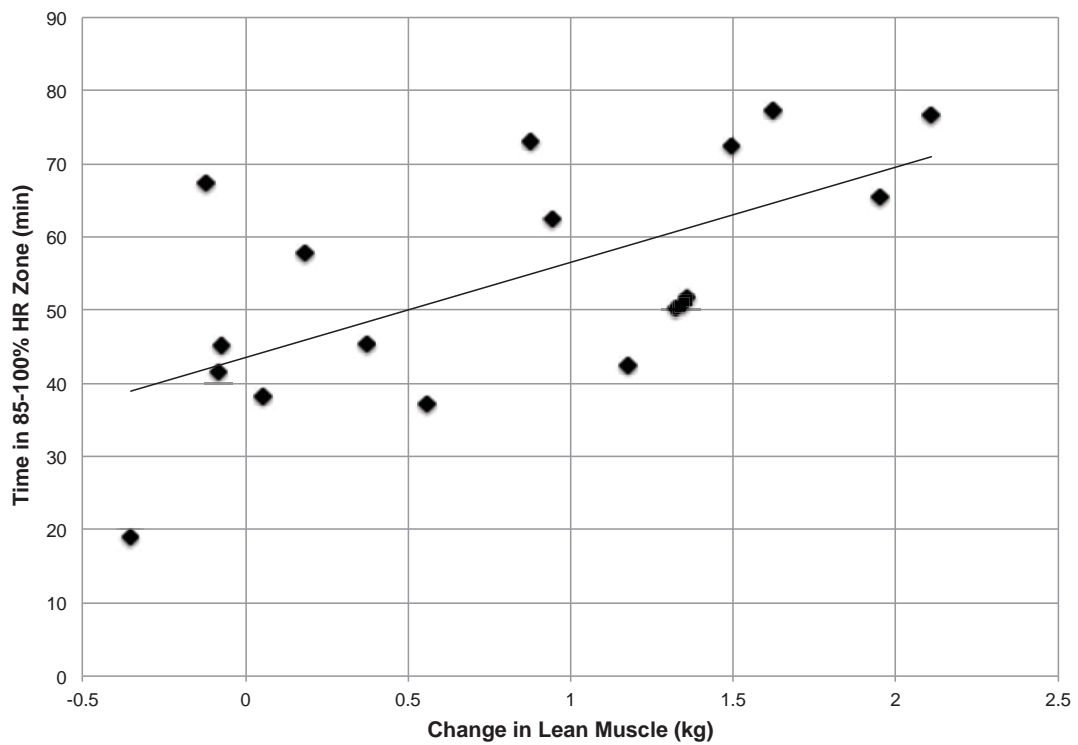


Figure 1. Correlation of change in lean mass to time spent in 85-100% heart rate zone. Pearson correlation coefficient = 0.627.

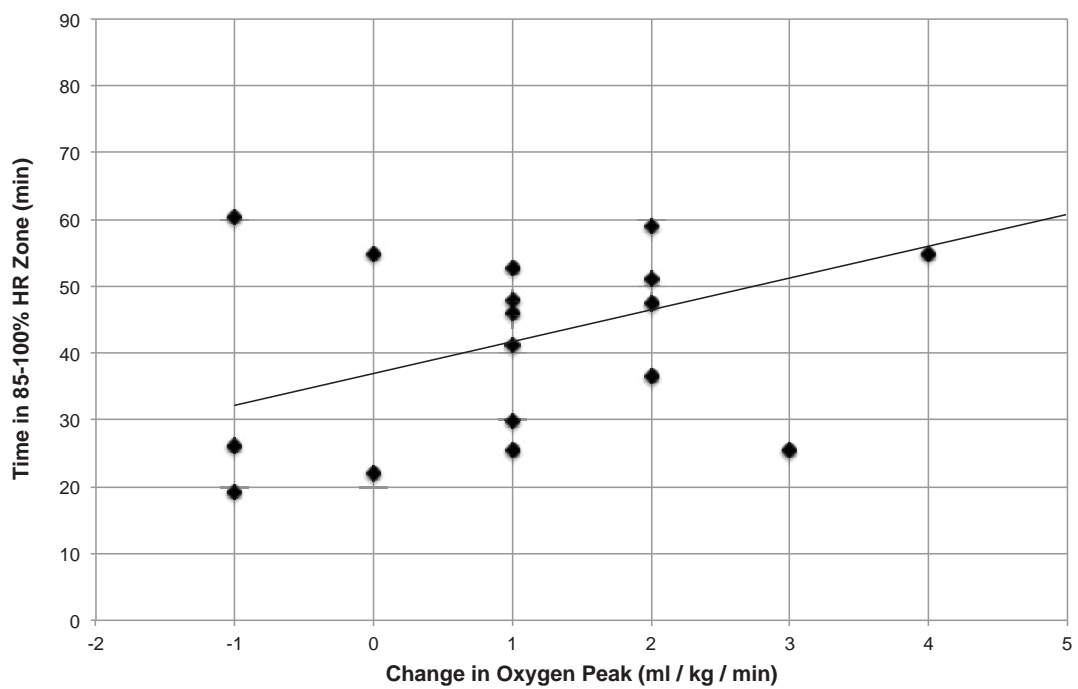


Figure 2. Correlation of change in VO_{2max} to time spent in the 85-100% heart rate zone. Pearson correlation coefficient = 0.507.

interval times and specific exercises they each contain tracks geared towards agility, power, speed, and strength.

The governing body of collegiate soccer, the NCAA, limits teams during their winter offseason period to 8 coach-player contact hours per week and dictates that only 2 of those hours can involve training with a soccer ball. The collegiate winter offseason period is treated differently in each university soccer program based on the coaches' philosophy and perhaps the environmental as well as logistical parameters. Some coaches do not dictate the specific training protocols and allow their players the freedom to make their own training choices¹⁶. Some may still organise and direct training but will minimise the frequency of training during this period¹⁷. In the past, the participants in the current study, have utilised all 8 of the allowed hours each week in their offseason training. The traditional offseason protocol for this group was reported as: 2.0 hours of technical work with a soccer ball, 2.5 hours of Olympic-style lifting, 1.0 hour of steady state long distance running, 1.0 hour of interval running (800m, 400m, and 300m distances primarily), 1.5 hours of sprint and agility training. Therefore the type of HIIT training in this study is a substantial departure from the customary offseason training. Based on past data from this soccer program's fitness testing, the typical 8-hour per week offseason program did not produce significant improvements in either body composition or oxygen consumption during the offseason period. But in the current study, we reported significant improvements in training status that were accomplished utilising just 5 of the allowed 8 hours per week.

In a 90 minute soccer game, a player may cover anywhere from 9-12 km with close to 1000 distinct anaerobic episodes, high intensity running every 70 seconds, and a full sprint every 90 seconds^{2,12}. Improvements in training status; lean body mass and VO_{2max} ; have been linked to performance parameters during a soccer game such as distance covered on the field, number of sprints, and number of touches on the ball^{3,4,5}. This study shows that time spent in the 85-100% heart rate

zones positively correlates to improvements in training status as well as a significant difference between pre- and post-training measures. To sum, the athletes spent a great deal of time in the 85-100% zones during the HIIT sessions and most experienced gains in both lean body mass and VO_{2max} . The next step would be to find the correlation between training intensity and game performance. This is an important link particularly as heart rate monitoring becomes more prevalent among soccer teams.

Another future direction may be to evaluate the prevalence of overuse injuries sustained by soccer players in the offseason. There is substantial evidence that high volume running contributes to lower extremity injury¹⁸. Because the HIIT protocol did not involve as much running as the traditional training protocol of most soccer teams, we believe that application of this may help prevent overuse injuries in soccer athletes.

Limitations

It is possible that improvements in body composition were in part due to changes in nutritional intake. It is also feasible that lean body mass improvements were impacted, at least in part, by the concurrent strength training of Les Mills BODYPUMP™. However, because of the correlation between lean body mass and time spent in the 85-100% zones, it seems likely that the improvements were in large part a result of the training intensity of the LES MILLS GRIT™ and the soccer training sessions.

CONCLUSIONS

HIIT may be an effective and time efficient way of training elite women soccer players in the offseason. In a typical offseason training program, these athletes would train 8 hours per week, however in this study, they trained for only 5 hours per week and experienced training status improvement in most cases.

Perhaps the most important practical application of this study is to add variety to training. If the primary factor contributing to improvements in lean

body mass and VO_{2max} is intensity, then there are a variety of effective methods to incorporate. During the offseason, as well as during the competitive season, regular soccer practice and all types of running could be supplemented with alternative workouts of the same or even greater intensity to help vary the training stimulus.

In summary, the results of the current study indicate a moderate correlation between time spent in the 85-100% heart rate zone and improvements in lean body mass and VO_{2max} . We found HIIT to be a productive and time-efficient method of training in the 85-100% zone. These data suggest that HIIT can be an effective protocol in a well-trained college athlete cohort and may maximise competition performance and minimise training time.

CONFLICT OF INTEREST

Dr. Jinger S. Gottschall is a co-owner of FITOLOGY, LLC group fitness and cycling studio where the training sessions were completed.

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