ABSTRACT

The aim of the current study was to assess the changes in resting heart rate, peak heart rate and VO\textsubscript{2} max during a periodized training year of handball players. Testing took place at four points during the periodized training year: at the beginnings of general preparation (T1), specific preparation (T2), and competition phase beginning (T3) end of competition phases of training and peaking (T4). Resting heart rate, peak heart rate and VO\textsubscript{2} max was selected as criterion variables. The repeated measures of analysis of variance (ANOVA) indicated a significant differences between testing sessions for resting heart rate (F = 8.05, p < 0.05), peak heart rate (F = 4.51, p < 0.05) and VO\textsubscript{2} max (F = 4.95, p < 0.05). It is concluded that resting and peak heart rate along with VO\textsubscript{2} max altered during a periodized training year of handball players. This study clearly shows the impact of training during different phases of periodized training year on oxygen consumption of the body and cardiorespiratory fitness because oxygen delivery to tissues is dependent on lung and heart function.

INTRODUCTION

Resting heart rate refers to the number of times a heart contracts in one minute (beats per minute or BPM) while at complete rest. The normal heart rate depends upon your age, gender and health and can vary greatly for both athletes and non-athletes. In general, a person’s resting heart rate indicates their basic fitness level. The stronger the heart, the more blood it can pump during each contraction, and the less frequently it needs to beat to get adequate blood flow (circulation) and oxygen to the body tissues. A well-trained athlete can have a very low resting heart rate and pump more blood than an unconditioned individual. However, in well-trained endurance athletes, with much higher cardiac outputs (which is the product of heart rate and stroke volume), pulmonary diffusion may become a limiting factor to VO\textsubscript{2}max. The very high cardiac outputs that highly trained athletes attain shortens the time period for blood to pick up oxygen in the lungs, possibly leading to lower blood oxygen saturation levels (Robers & Roberts 1997). Despite this possibility, pulmonary diffusion is thought to play a minor role in the overall limitation of oxygen delivery for endurance performance.

Fitness testing and monitoring of training intensities are now becoming common place in the modern game. In most sports training for successful competition has become a year-long challenge. To assist in preparation, an athlete’s year is often periodised or divided into distinct phases where training is reduced or increased according to competition commitments. Measuring physiological parameters throughout a competitive season and across consecutive seasons give an assessment of how fitness fluctuates across the year. It is important to assess existing training schedules through rigorous sport specific fitness testing of athletes at defined points in the competitive season. This will evaluate both physical performance and the existing training strategies (Denguezli, et al., 2008). The aim of the current study was to assess the changes in resting heart rate, peak heart rate and VO\textsubscript{2} max during a periodized training year of handball players.

MATERIALS AND METHODS

Subjects

The subjects employed in the present study were fourteen male handball players from the Annamalai University team (Mean ± SD: Age 23.0 ± 3.4 years, Height 174.7 ± 7.9 cm, Body Mass 69.4 ± 6.1 kg) preparing for the 2013 South Zone Inter University handball tournament. All the players had been part of the team for a minimum of 2 years. All subjects were familiar with all the testing that took place, which included both field and laboratory assessments.

Testing Procedure

Testing took place at four points during the periodized training year: at the beginnings of general preparation (T1), specific preparation (T2), and competition phase beginning (T3) end of competition phases of training and peaking (T4). A full testing battery was conducted at T1 and T4, while two minor testing sessions were conducted at T2 and T3. The study commenced after the end of the previous competitive season and at the beginning of the general preparation phase of training. The handball training year was divided into three mesocycles (general preparation, March to May; specific preparation, June to August; competition, September to November). The players...
trained daily and thus it is not possible to quantify exact training loads. The subjects had been instructed to refrain from strenuous exercise for forty-eight hours prior to testing and to avoid food and caffeine intake for two hours preceding the assessments. All subjects completed testing at the same time of day to avoid any circadian rhythm effects.

**Variables and Tests**

Resting heart rate, peak heart rate and VO$_2$ max was selected as criterion variables. VO$_2$ max of handball a player was measured through Yo-Yo intermittent recovery test level II. The players were administered with ten minutes of warming up. Then players were asked to line up in front of twenty meter marked area with cones. The tester instructs the subjects to run half way and return to the starting point when the sound signal produced from music player. The tester keeps recording the distance covered by the players. We used formula for estimation of VO$_2$ max = distance in meter × 0.0136 + 45.3 (Bangsbo et al. 2008). The polar heart rate monitor was fixed during Yo-Yo test from which we assessed maximum exercise heart rate and at resting condition resting heart rate was measured.

**Statistical analyses**

Descriptive statistics were calculated for all variables. A repeated measures analysis of variance (ANOVA) was utilized to determine significant differences for each variable between the testing sessions. Bonferroni post-hoc test was used to locate differences between testing sessions. Significance level was set at P < 0.05. All statistical analyses were conducted using SPSS v11.5.

**RESULTS**

Descriptives (mean ± SD) of the results can be found in Table 1. Repeated measures of analysis of variance (ANOVA) indicated significant differences for each variable between testing sessions. Bonferroni post hoc test was used to determine significant differences for each variable between testing sessions. Significance level was set at P < 0.05. All statistical analyses were conducted using SPSS v11.5.

<table>
<thead>
<tr>
<th>Variables</th>
<th>T1</th>
<th>T2</th>
<th>T3</th>
<th>T4</th>
<th>F</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Resting heart rate (bpm)</td>
<td>57.91 ± 2.17</td>
<td>53.66 ± 3.43*</td>
<td>55.91 ± 4.26</td>
<td>55.33 ± 3.10</td>
<td>8.05</td>
<td>&lt; 0.05</td>
</tr>
<tr>
<td>Peak heart rate (bpm)</td>
<td>185.86 ± 14.78</td>
<td>182.01 ± 15.03</td>
<td>184.50 ± 17.76</td>
<td>184.08 ± 16.62</td>
<td>4.51</td>
<td>&lt; 0.05</td>
</tr>
<tr>
<td>VO$_2$ max (ml/kg/min)</td>
<td>59.91 ± 3.15</td>
<td>61.09 ± 2.48</td>
<td>60.84 ± 2.14</td>
<td>60.81 ± 3.09</td>
<td>4.95</td>
<td>&lt; 0.05</td>
</tr>
</tbody>
</table>

**DISCUSSION ON FINDINGS**

**Resting heart rate**

In this study resting heart rate and peak heart rate showed changes during a periodized training year handball players. When the players are exposed to specific preparation they demonstrated 7.30% reduction in resting heart rate, there after it maintained till the end. Similarly, peak heart rate also showed changes during a periodized training year of handball players. They recorded 2.01% reduction in peak heart rate. Chittibabu and Akilan (2013) stated that basketball specific endurance circuit training for high school basketball players displayed a significant reduction in resting and peak heart rate. In the present study when players are exposed to specific training phase from general preparation they demonstrated attributed the seasonal decrement to the fact that coaches may be reducing the training stimulus towards the end of the season. The increase in body mass and percent body fat in players had a negative effect on aerobic capacity.

**CONCLUSION**

The current study is the first to examine the cardiovascular changes of handball players over the course of a periodized training year. It is concluded that resting and peak heart rate along with VO$_2$ max altered during a periodized training year of handball players. This study clearly shows the impact of training during different phases of periodized training year on oxygen consumption of the body and cardiorespiratory fitness because oxygen delivery to tissues is dependent on lung and heart function.
References


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