ACCUTE EFFECT OF RECOVERY REGARDING DIFFERENT BODY POSITION

Jaroslav Kristofic and Tomas Maly

Faculty of Physical Education and Sport, Charles University in Prague, Czech Republic

Abstract

Purpose: The aim of the study was to compare heart-rate recovery (HRR) during inactive recovery in three positions of the body (upright seated position, horizontal supine position and decline supine position) in trained participants after load on aerobic threshold. Material and method: The sample consisted of 16 subjects (age = 21.5±1.4 years, body height 178.5±6.7 cm, body weight 77.5±5.9 kg). The participants ran on the spot on a soft gymnastics mat for 3 minutes to reach and keep aerobic threshold during the last minute. For the next 2 minutes, the participants relaxed in the defined position of sitting on a mat (R1), lying on a mat (R2) or lying on the decline plane (R3) where the angle to the mat was 30 degrees. HRR was measured immediately after load (T1) and during the recovery phase in 16 second intervals (T2), in 30 s (T3), 60 s (T4) and 120 s (T5) after the cessation of exercise. Results: Multiple analysis of variance showed a significant effect of two main factors on differences in heart rate (time: $F_{2.2,97.5} = 565.44, p<0.01, \eta^2 = 0.93$, recovery: $F_{2,45} = 4.98, p<0.05, \eta^2 = 0.18$). Post-hoc analysis revealed significant differences in HRR under the influence of time in each type of recovery up to T4 (60 s). While sitting (R1), a significant decrease in HRR between T4 (89.25±10.92 beats.min$^{-1}$) and T5 (80.38±11.88 beats.min$^{-1}$) (p<0.01). It was found: in horizontal supine position (R2): 82.00±11.92 vs. 80.31±13.51 beats.min$^{-1}$) and decline supine position (R3: 80.19±9.66 vs. 77.25±11.56 beats.min$^{-1}$) no significant changes appeared. Discussions and conclusion: The results showed a significant effect of time and body posture on recovery processes. A higher level of HRR was detected in supine positions compared to the seated position in the first minute of recovery. The level of HRR in horizontal and decline supine positions was almost identical in the first minute; however, in following phases a greater decrease in HRR was found in the decline supine position. The demonstrated effect of body posture on the speed of recovery is a kind of information directly applicable in practice, especially in sports with intermittent load.

Key words: heart rate, heart rate recovery, body position, exercise

Introduction

Physical load induces physiological reactions in the body which differ according to type of load, its intensity and duration. During exercise, the sympathetic nervous system controls body function, but post-exercise there is a shift in the autonomic nervous system and the parasympathetic system reactivates to return the body to a resting state (Buchheit, Laursen, & Ahmaid, 2007; Buchheit, Papelier, Laursen, & Ahmaid, 2007). Increased sympathetic activity combined with parasympathetic withdrawal (e.g. during exercise) leads to reduced skin blood flow and increased blood flow to the muscles (Seals & Victor, 1991). Heart rate is primarily controlled by the autonomous nervous system and activity of sympathetic and vagus is modulated by central and peripheral oscillators (Heller & Vodicka, 2011). Such studies have shown that post-exercise decreases in heart rate are almost exclusively controlled by parasympathetic reactivation as opposed to sympathetic withdrawal (Otsuki et al., 2007). Heart rate (HR) response to exercise allows non-invasive assessment of the behaviour of the cardiovascular system during effort, as well as to determine the subjects’ fitness level. HR is easily monitored and can be used to control the intensity of aerobic exercises (Achten & Jeukendrup, 2003). Heart rate reacts very quickly to changes during the load, while the most sensitively it reacts to increased intensity and resistance (Neumann, Pflutzer, & Hottenrott, 2005).

An important variable of the organism’s response to the load is heart-rate recovery (HRR). Heart-rate recovery (HRR) can be defined as the rate at which heart rate declines, usually within minutes of the cessation of physical exercise (Borresen & Lambert, 2007). Buchheit, Papelier, et al. (2007) define HRR as the rate at which the heart rate decreases to a resting rate after cessation of moderate to heavy exercise. Jones and Dean (2004) reported that body position and body position changes determine the gravitational gradient that acts on the cardiovascular and cardiopulmonary systems, from moment to moment, and affects optimal blood flow and oxygen transport. Gravity directly influences lung volumes and capacities, and respiratory mechanics. The effect of acceleration of HRR in the supine position compared to upright sitting position was pointed out in a study by (Takahashi, Okada, Saitoh, Hayano, & Miyamoto, 2000). In the upright position, blood from the central venous system is shifted to the lower extremities, eliciting an increase in the sympathetic mediated vasomotor activity for the preservation of arterial blood pressure (Hainsworth, 2000). Changes of position in the relaxation phase after load influence not only HRR but also hemodynamic parameters. Some studies suggested that physical exercises can promote decline of BP (blood pressure) after cessation of exercise in comparison to BP prior to exercise (Fisher, 2001; Floras et al., 1989).
Available literature offers a relatively wide range of knowledge concerning comparison of HRR regarding different types of recovery (active vs. inactive) or in different types of body posture (upright position vs. supine position). There is, however, a lack of information concerning comparisons of HRR in the decline position which causes other hemodynamic changes in the athlete’s body. The aim of the study was to compare HRR during inactive recovery in three positions of the body (upright seated position, horizontal supine position and decline supine position) in trained participants after load on aerobic threshold.

**Methods**

**Study sample**

The screened sample consisted of 16 subjects (age = 21.5±1.4 years, body height 178.5±6.7 cm, body weight 77.5±5.9 kg). The participants were selected from university students of physical education and sport (n=86) using a randomised procedure. Sport specialisation or individual physical fitness did not influence inclusion into the screened sample. On the other hand, the pre-condition was good general health without contraindications in the field of physiological and psychological functions. The participants received a verbal description of the study procedures before testing and completed written informed consent that was approved by the ethical committee of the Faculty of Physical Education and Sport, Charles University in Prague. Measurements were performed according to the ethical standards of the Helsinki Declaration and the ethical standards in sport and exercise science research described by (Harriss & Atkinson, 2011).

**Methods of data collecting**

The participants ran on the spot on a soft gymnastics mat (the height of mat was 18 cm) for 3 minutes. From the beginning of the second minute until the end of the interval, the participant’s task was to keep heart rate at the level of aerobic threshold (± 2 beats). After the load, heart rate was measured using sporttester Polar RS800 (Polar Electro OY, Kempele, Finland). For the next 2 minutes, the participants relaxed in the defined position of sitting on a mat (R1), lying on a mat (R2) or lying on the decline plane (R3) where the angle to the mat was 30 degrees (the head was lower than the trunk and limbs). The order of tests was randomised in participants. During the relaxation phase, the participants were isolated from the surroundings so that the recovery processes were not influenced by external factors. The measurement was separately repeated three times with breaks. Heart rate was measured immediately after load (T1) and during the recovery phase in 16 second intervals (T2), in 30 s (T3), 60 s (T4) and finally 120 s (T5) after the cessation of exercise. In 24 hours prior to the measurements, the participants did not consume any medications (including alcohol and caffeine) or pharmacological agents that could influence the results of the measurement.

They were also told not to eat or drink before the measurement. Furthermore, 48 hours before the tests the subjects did not perform high intensity physical activity. All tests were carried out in the morning between 10a.m. – 12p.m.

**Statistical analysis**

Data are presented as mean ± standard deviation. The normality of distributions was checked using the Shapiro-Wilks test. Descriptive statistics were calculated for each test and recovery time. Significant differences in heart rate during the time were evaluated using the mixed model of analysis of variance for repeated measurements (RM ANOVA 3x5), which compares the variance of within-group effect (time) and between-group effect (type of recovery). The comparison of heart rate between the respective time intervals was assessed using the multiple comparisons of means (Bonferroni’s post-hoc test). To evaluate equality of error variances, Levene’s test was used. When the criterion of sphericity as one of the conditions of ANOVA, which was assessed using Mauchly’s test (χ²), was not met, degrees of freedom were adjusted by means of Greenhouse-Geisser’s (GG) sphericity correction and then the statistical significance was assessed according to particular degrees of freedom. Rejection of the null hypothesis was assessed at the level of p<0.05.

Effect size was assessed using the “Eta square” coefficient (η²), which explains the proportion of variance of the monitored factor. Effect size was examined as follows: η²=0.20 – small effect, η²=0.50 – medium effect and η²=0.80 – large effect(Cohen, 1992). The probability of type I error (alpha) was set at 0.05 in all statistical analyses. The probability of type II error (beta) was controlled using post hoc (retrospective) analysis and it was set at 0.2 (conventional value) by G*Power (version 3.1.9., Kiel University, Germany). Statistical analysis was performed using IBM® SPSS® v21 (Statistical Package for Social Science, Inc., Chicago, IL, USA).

**Results**

Multiple analysis of variance showed a significant effect of two main variables on differences in heart rate (time: $F_{2,2,97.5} = 565.44, p<0.01$, η² = 0.93, recovery: $F_{2,45} = 4.98, p<0.05$, η² = 0.18). The change in heart rate in relation to the position of the athlete’s body during recovery and to time of recovery is presented in Figure 1. Post-hoc analysis revealed significant differences in heart rate under the influence of time in each type of recovery up to T4 (60 s). While sitting (R1), a significant decrease in HR between T4 (89.25±10.92 beats.min⁻¹) and T5 (80.38±11.88 beats.min⁻¹) (p<0.01) was found; in the horizontal supine position (R2: 82.00±11.92 vs. 80.31±13.51 beats.min⁻¹) and decline supine position (R3: 80.19±9.66 vs. 77.25±11.56 beats.min⁻¹) no significant changes appeared (presented by Figure 1). A descriptive profile of recovery is presented in Table 1.
Table 1 Comparison of changes in heart rate in relation to body posture during recovery. Data are expressed as mean (standard deviation).

<table>
<thead>
<tr>
<th></th>
<th>T1</th>
<th>T2</th>
<th>T3</th>
<th>T4</th>
<th>T5</th>
<th>F</th>
<th>p</th>
<th>η²</th>
</tr>
</thead>
<tbody>
<tr>
<td>R1</td>
<td>141.25(4.07)</td>
<td>123.69 (7.44)</td>
<td>111.56(8.41)</td>
<td>89.25(10.92)</td>
<td>80.38(11.88)</td>
<td>200.72</td>
<td>p&lt;0.01</td>
<td>0.93</td>
</tr>
<tr>
<td>R2</td>
<td>138.50(5.66)</td>
<td>115.88 (8.58)</td>
<td>98.94(10.39)</td>
<td>82.00(11.92)</td>
<td>80.31(13.51)</td>
<td>185.63</td>
<td>p&lt;0.01</td>
<td>0.93</td>
</tr>
<tr>
<td>R3</td>
<td>137.94(5.67)</td>
<td>113.19 (11.57)</td>
<td>96.81(12.14)</td>
<td>80.19(9.66)</td>
<td>77.25(11.56)</td>
<td>184.94</td>
<td>p&lt;0.01</td>
<td>0.93</td>
</tr>
<tr>
<td>Sig.</td>
<td>N.S.</td>
<td>R1 vs R3 (p&lt;0.01)</td>
<td>R1 vs R2,R3 (p&lt;0.01)</td>
<td>R1 vs R3 (p&lt;0.01)</td>
<td>N.S.</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

R1 – sitting position, R2- supine position, R3 – decline supine position, T1 – heart rate after load, T2 – heart rate after 16s, T3 – heart rate after 30s, T4 – heart rate after 60s, T5 – heart rate after 120 s, Sig. – comparison of heart rate between the type of body posture during recovery in the particular time interval, N.S. – non-significant.

Discussion

The aim of this paper was to examine the effect of body posture on heart rate recovery. The results showed significant differences in dynamics of HRR decrease in supine positions (R2,R3) in comparison to the upright seated position (R1). After 30 seconds, HRR decreased by 16.3 % in the horizontal supine position (R2) and by 17.9 % in decline supine position(R3). In case of the seated position, HRR decreased by 12.4%. One minute after load the following declines in HRR in the different types of body postures were observed: R1 = 36.8%, R2 = 40.8% a R3 = 41.86%. No significant changes were detected between R2 and R3. The course of recovery processes is not linear. HRR after aerobic load decreases exponentially in two phases. The fast decay in HR observed after exercise could occur, mainly, due to parasympathetic reactivation; and afterwards the reduction in HR would be attributed to lowered sympathetic activity(Fernandez, Adami, Pereira Costa, Lima Silva, & De-Oliveira, 2006). HRR is the topic of several studies where the authors found different hear rate recovery and other variables under the influence of body posture.Canales et al. (2006) monitored values of HR, blood pressure (BP) and stroke volume (SV) 2 minutes after load in the prone and supine position.

While HR values in the prone position were significantly higher than in the supine position, they did not appear significant in hemodynamic variables of BP and SV. The lack of major hemodynamic differences suggests that central command is restored more quickly when supine. The authors state that changes in HRR in the prone and supine positions may be related to different load of baroreceptors. In our study we moved from traditional prone and supine positions into a comparison of HRR in the upright seated, horizontal and decline supine positions (decline by 30 degrees) where the head was lower than other body segments. We proved, similarly to(Barak et al., 2011) a significant improvement of HRR in the supine position in comparison to the seated position. Similarly as in their comparison between horizontal supine position and supine position with elevated legs our study also revealed non-significant difference in HRR between the horizontal and decline supine position.

The decline supine position was used so that the legs were higher than heart and maintaining this position would not require any physical load. The course of changes in HRR between R2 and R3 was almost identical in the first minute of recovery. However, in the case of the decline supine position (R3) HR decreased between T4-T5 (the second minute of recovery) by 3.4% and in the horizontal supine position (R2) by 2.1%. Although this result was not statistically significant, in terms of effect size it could be a very interesting point. One of the study limits wasthat fact that only inactive form of recovery was used.Barak et al. (2011) enriched the field of HRR study by incorporating other variable, i.e. changes in HRR in relation to active or inactive recovery. Inactive recovery is self-regulated recovery of the organism when, during and after the load, the balance between physiological functions is interfered and the organism tends to return these processes to the level of initial values. On the contrary, active recovery means an external intervention when various invasive means, methods and procedures for acceleration the passive process of recovery are used. The authors in their study focused on monitoring HRR after load in inactive recovery in the upright seated position, active recovery in the upright seated position (riding a bicycle), passive supine position and passive supine position with elevated legs. Barak et al. (2011) reported that the supine position with or without elevated legs accelerated HRR compared to the two seated positions.

Figure 1 Changes in heart rate during recovery

The decline supine position was used so that the legs were higher than heart and maintaining this position would not require any physical load. The course of changes in HRR between R2 and R3 was almost identical in the first minute of recovery. However, in the case of the decline supine position (R3) HR decreased between T4-T5 (the second minute of recovery) by 3.4% and in the horizontal supine position (R2) by 2.1%. Although this result was not statistically significant, in terms of effect size it could be a very interesting point. One of the study limits wasthat fact that only inactive form of recovery was used.Barak et al. (2011) enriched the field of HRR study by incorporating other variable, i.e. changes in HRR in relation to active or inactive recovery. Inactive recovery is self-regulated recovery of the organism when, during and after the load, the balance between physiological functions is interfered and the organism tends to return these processes to the level of initial values. On the contrary, active recovery means an external intervention when various invasive means, methods and procedures for acceleration the passive process of recovery are used. The authors in their study focused on monitoring HRR after load in inactive recovery in the upright seated position, active recovery in the upright seated position (riding a bicycle), passive supine position and passive supine position with elevated legs. Barak et al. (2011) reported that the supine position with or without elevated legs accelerated HRR compared to the two seated positions.

The decline supine position was used so that the legs were higher than heart and maintaining this position would not require any physical load. The course of changes in HRR between R2 and R3 was almost identical in the first minute of recovery. However, in the case of the decline supine position (R3) HR decreased between T4-T5 (the second minute of recovery) by 3.4% and in the horizontal supine position (R2) by 2.1%. Although this result was not statistically significant, in terms of effect size it could be a very interesting point. One of the study limits wasthat fact that only inactive form of recovery was used.Barak et al. (2011) enriched the field of HRR study by incorporating other variable, i.e. changes in HRR in relation to active or inactive recovery. Inactive recovery is self-regulated recovery of the organism when, during and after the load, the balance between physiological functions is interfered and the organism tends to return these processes to the level of initial values. On the contrary, active recovery means an external intervention when various invasive means, methods and procedures for acceleration the passive process of recovery are used. The authors in their study focused on monitoring HRR after load in inactive recovery in the upright seated position, active recovery in the upright seated position (riding a bicycle), passive supine position and passive supine position with elevated legs. Barak et al. (2011) reported that the supine position with or without elevated legs accelerated HRR compared to the two seated positions.
Active recovery in the seated upright position was associated with slower HRR compared to inactive recovery in the same position. Similar results were also reported by (Labudová & Pavlovoňová, 2010) who investigated the effect of body posture on the heart rate of swimmers in water. HR value in the supine position was lower by 12 beats.min⁻¹ on average than in a quiet stance in water in their monitored group. The next limit to the study is monitoring recovery processes only through the HR variable. An interesting result could be found in case of examining other hemodynamic variables (e.g. blood pressure) or heart rate variability. Analysis of heart rate variation (HRV) has become a popular non-invasive tool for assessing the activities of the autonomic nervous system. HRV analysis is based on the concept that fast fluctuations may specifically reflect changes of sympathetic and vagal activity (Rajendra Acharya, Subbanna Bhat, Kannathal, Rao, & Min Lim, 2005). High variability is indicative of cardiovascular health whereas low variability is indicative of cardiovascular impairment (Borresen & Lambert, 2008). HRR and heart-rate variability have been identified as powerful indicators of an individual’s well-being and physiological training status due to their close link with the autonomic nervous system (Buchheit, Papelier, et al., 2007). The effect of body posture on HRR is undeniable. The reason for this phenomenon can be found in different hemodynamic conditions in relation to cardiovascular functions and work of receptors. Values of HR during and after load are influenced by a number of factors which include individual level of physical fitness. The organism of a trained individual reacts to load more effectively, i.e. lower heart rate and higher systolic blood pressure (Heller & Vodicka, 2011). Values of HR can also be influenced by psychological, pharmacological or pathological factors or other external factors. The fact that the level of HRR is influenced by previous adaptation to specific load was confirmed in a study by (McDonald, Grote, & Shoepe, 2014). They reported that after identical load HRR was faster in road cyclists (aerobic training) than in track cyclists (anaerobic training) after one and two minutes of recovery with a statistical significant difference. This suggests that there may be more factors at work in lowering post-exercise heart rate than parasympathetic alone such as blood metabolites, type of previous exercise training and type of exercise during the assessment (e.g. anaerobic vs. aerobic) (McDonald et al., 2014). Respiration, blood pressure and heart rate are not isolated components but rather a dynamic system which is internally connected by a number of bonds (Souček & Kára, 2002). Evaluation of HRR in relation to body posture using sportstesters is a technically simple measurement with a relatively high degree of possible standardization of conditions. Nevertheless, it is necessary to admit that measured HR values can be influenced by plenty of other factors, such as emotions, current psychological state, temperature of the surroundings, etc.

Conclusion
The demonstrated effect of body posture on the speed of recovery is a kind of information directly applicable in practice, especially in sports with intermittent load. However, this phenomenon will always depend on the particular conditions and possibilities of different sport disciplines. What is important is a demonstrated shortening of time needed for recovery in relation to body posture. The results showed a significant effect of time and body posture on recovery processes. A higher level of HRR was detected in supine positions compared to the seated position in the first minute of recovery. The level of HRR in horizontal and decline supine positions was almost identical in the first minute; however, in following phases a greater decrease in HR was found in the decline supine position. The results of the study cannot be generalized due to the number of subjects but they can serve as a basis for further studies in clinical conditions.

References


# AKUTNÝ EFEKTI OPORAVKA NEOVISNO O POLOŽAJU TIJELA

**Sažetak**

Namjena: Cilj istraživanja bio je usporediti stopu oporavka srca (HRR) tijekom neaktivnog oporavka u tri položaja tijela (uspravnom sjedalicom položaja, vodoravnom ležećem položaju i otklonjenom ležećem položaju) u obučenih sudionika nakon opterećenja na aerobnom pragu. Materijal i metode: Uzorak se sastojao od 16 ispitanika (dob = 21.5 ± 1.4 godina, tjelesna visina 178.5 ± 6.7 cm, tjelesne težine 77.5 ± 5.9 kg). Sudionici su trčali na mjestu na mekanoj gimnastičkoj strunji 3 minute, postignući aerobni prag u posljедnjoj minuti. Za sljedećih 2 minute, sudionici su opušteni u definiranom položaju na strunji (R1), ležeći na strunji (R2) ili leži na ravnini (R3), gdje je kut na tepih bio 30 stupnjeva. HRR je mjeren neposredno nakon opterećenja (T1) i tijekom faze oporavka u intervalima od 16 sekundi (T2), u 30-ih (T3), 60 s (T4) i 120 s (T5) nakon prestanka vježbanja. Rezultati: Višestruka analiza varijance pokazala je značajan učinak dvaju glavnih čimbenika na razlike u otkucanjima srca (vrijeme: F2,49,1 = 565,44, p <0,01, η2 = 0,93, oporavak: F2,49,1 = 4,98, p <0,05, η2 = 0,18). Post-hoc analiza pokazala je značajne razlike u HRR pod utjecajem vremena u svakoj vrsti oporavka do T4 (60 s), dok je sjedu (R1), zabilježen značajan pad u HRR između T4 (89.25 ± 10.92 otkucaja min⁻¹) i T5 (80.38 ± 11.88 beats.min⁻¹) (p <0,01). Nađeno je: u horizontalnom ležećem položaju (R2: 82.00 ± 11.92 vs 80.31 ± 13.51 beats.min⁻¹) i ležećem položaju (R3: 80.19 ± 9.66 vs 77.25 ± 11.56 beats.min⁻¹) nije bilo značajnih promjena. Rasprava i zaključci: Rezultati su pokazali značajan učinak vremena i držanja tijela na procese oporavka. Otkrivena je veća razina HRR u ležećem položaju u odnosu na sjedalic položaj u prvoj minuti nadoknade. Razina HRR u horizontalnom i opadanje u ležećem položaju je gotovo identična u prvoj minuti; Međutim, u sljedećim fazama pronađen je veći pad HRR u ležećem položaju po kuter. Pokazani učinak držanja tijela na brzinu oporavka je informacija koja se izravno primjenjuje u praksi, npr. u sportovima s isprekidanim opterećenjem.

**Klíučné riešči:** srčani ritam, oporavok srčanog ritma, položaj tijela, vježba

Received: February 10, 2015
Accepted: April 20, 2015
Correspondence to:
Tomas Malý, PhD.
Faculty of physical education and sport
Charles University
16252 Prague, Jose Martiha 31, Czech Republik
Phone: +20 77 653 11 43
E-mail: tomimaly@yahoo.com

This project was supported by PRVOUK P38.