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Original Article

The importance of heart rate monitors in controlling intensity during training and competition in junior biathlon athletes

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ABSTRACT

Purpose: This study examines whether junior athletes successfully regulate training intensity using subjective feeling, or whether heart rate monitor is necessary to regulate intensity. Methods: Nine active junior biathlon athletes, men (n = 6) and women (n = 3) between 16 and 19 years old participated in the study. All participants completed two training sessions at lactate threshold, one session regulated by subjective feeling, blinded for heart rate and one session regulated by heart rate. Results: The participants start the first ten minutes of the training session at lower intensity when blinded, compared to using HR monitors (ES, 0.98; P = 0.05). Registrations at 20 and 30 minutes shows that participants in the non-blinded session gradually tune in to the right intensity, and the differences get smaller and non-significant. Mean speed (ES, 0.61; P = 0.04) and distance covered (ES, 0.63; P = 0.04) during the training session is larger in the heart rate controlled session compared to subjective feeling. Conclusions: Using heart rate monitors provide better control of exercise intensity in young biathletes than subjective feeling. Using subjective feeling underestimate intensity at lactate threshold, and results in significantly, lower distance covered. **Key words:** TRAINING INTENSITY, INTENSITY REGULATION, LACTATE THRESHOLD

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INTRODUCTION

Biathlon is a sport that combines cross-country skiing and rifle shooting. Athletes competing in biathlon meet high demands in endurance to perform well in cross-country and to control intensity at the shooting range. The Norwegian Biathlon Federation (s.a), recommend junior biathletes to train between 400 and 675 hours per year. Studies examining training intensity distribution among highly trained endurance athletes shows that 75% of training is performed at low intensity below the lactate threshold, 8-17 % is performed at intensity above lactate threshold (Seiler and Kjerland 2006), and thus only a small amount of training is performed at the lactate threshold. With such an extensive amount of training, distribution and regulation of exercise intensity is crucial to gain optimal effects of endurance training (Laursen 2010), and to avoid overtraining (Foster 1998).

Lactate threshold can be defined as the highest work –load, oxygen consumption or heart frequency in dynamic work using large muscle groups, where there is a balance between production and removal of lactate (Helgerud et al. 1990).

Since the speed at lactate threshold (LT) integrates both LT maximal oxygen consumption (VO_{2max}) and work economy, it is a strong determinant of endurance performance (Bassett and Howley 2000). According to McLaughlin et al. (2010) velocity at LT together with VO_{2max} and peak treadmill running velocity separately explains 80 % of a 16-km time trial performance. Previous studies have also reported a close relationship between running speed at the lactate threshold and 3000-metre performance time (Grant et al. 1997; Yoshida et al. 1993). Due to the close relationship between LT and endurance performance, being able to recognize and controlling the intensity at LT is essential to junior athletes competing in biathlon.

Rating of perceived exertion have been found to correlate well with heart rate (HR) measurements in regulation of both light and very high intensity exercise (Foster et al. 2001a). However, less experienced athletes may tend to perform easy training sessions to hard and hard training session to easy, and there appears to be a mismatch between the training plan designed by the coaches and the actual training executed by the athletes (Foster et al. 2001b). Underestimating intensity may potentially result in smaller distance covered during competition and training, and negatively affect performance. On the other hand, overestimating training intensity may give a too high load. The outcome may be reduced adaption of training, and in worst case lead to overtraining.

The aim of this study is therefor to investigate whether junior athletes successfully regulate training intensity using subjective feeling, or whether heart rate monitor is necessary to regulate intensity.

MATERIALS AND METHODS

Experimental approach

Since our aim is to investigate the junior biathlon athlete's ability to control exercise intensity using subjective sensation vs. heart rate monitoring, we used repeated measures design, where the participants served as their own controls.

Participants

We recruited nine active junior biathlon athletes, men (n = 6) and women (n = 3) between 16 and 19 years old to participate in the study. We recruited Participants by request for participation to a sports high school with a program for biathletes. Inclusion criteria were active participation in competition at regional and or national level. Exclusion criteria were disease and other inhibitory injuries. One participant dropped out of the study because of illness. Anthropometric and physiological characteristics of the eight participants are shown in Table 1. The Norwegian Centre for Research data approved the study. All participants reviewed and signed informed written consent forms prior to participation. The study conforms to the Declaration of Helsinki.

Table1. The table shows the anthropometric data and physiological characteristics of the participants.

	(N = 8)
Gender (men/Women)	3/4
Age	17.9 ± 1.01
Heigt (cm)	177 ± 11.7
Body mass (kg)	69.29 ± 8.86
VO_{2max}	
VO_{2max} (mL · Kg · min^{-1})	59.85 ± 6.83
RER_{max}	1.13 ± 0.02
HR_{max}	197.6 ± 7.2
Kmh_{max}	12.28 ± 1.11
LT	
HR_{LT}	174.7 ± 8.6
% HR_{max}	88.4 ± 2.1
$[La^-]_b$	3.30 ± 0.66

Data is presented as mean ± SD.

Procedures

We conducted three tests spread over non-consecutive days. Since blood lactate concentration $[La^-]_b$ may vary with diet (Yoshida 1986), we registered the diet the first test day. The same diet was followed all test days. In order to determine exercise intensity, on the first test day, we measured lactate threshold (LT) Maximal oxygen consumption (VO_{2max}) and maximal heart rate (HR_{max}).

Lactate threshold, VO_{2max} and HR_{max}

We used a treadmill (Life Fitness, Italy) calibrated for speed at an inclination of 5% to measure all physical capacity parameters. The test started with a warming-up period of 10 min at approximately 60% of predicted VO_{2max}, before establishing a baseline value of $[La^-]_b$. To determine LT, the subjects ran a maximum of five increasing intensities for 5 min at 60 to 95 % of VO_{2max}, with a 30s break for the determination of $[La^-]_b$ from a fingertip. After testing for LT, participants continued to run on the treadmill. We increased the speed every minute until reaching VO_{2max} (between three to six minutes). Oxygen consumption was measured every 10 seconds throughout the test (Cortex Metamax II (Cortex Biophysik GmbH, Leipzig, Germany). Metamax II has been validated against the Douglas bag technique (Larsson et al. 2004). We drew blood from the participants' fingertips to measure $[La^-]_b$ immediately after each participant reached VO_{2max} (Lactate Scout + SensLab, GmbH, Leipzig, Germany). Together with VO_2, we recorded HR during the whole test with Polar Accurex heart rate monitors (Polar Electro, Finland). HR_{max} is determined as the highest HR during the final minute.

Training sessions at LT

We registered HR during all training sessions with Polar Accurex heart rate monitors (Polar Electro, Finland). All participants completed one training session blinded for HR and one training session regulated by HR. Participants ran both training sessions on the same treadmill at 10 % inclination. We blinded speed on the treadmill, to avoid a possible carry over effect.

Protocols

Prior to inclusion, all participants were familiar with the concept lactate threshold. In addition, they received thorough information, written and oral, before included in the study.

The training session started with ten minutes warm up, where the participant was instructed to warm up at an intensity of approximately 70 % of HR_{max}. The speed was self-determined. We measured $[La^-]_b$ after the warm up, and for each ten minute during the session. Simultaneously we registered both heart rate and speed. After completing the training sessions, we asked the participants to rate the session on Borg scale.

1) *Training session regulated by subjective feeling (blinded session).*

We blinded the participants for speed and Heart rate during the whole session. After the warm up, the participants ran 30 minutes at the subjective feeling corresponding to lactate threshold.

2) *Training session regulated with heart rate monitors (non-blinded session).*

In this training session, participants ran 30 minutes at the heart rate corresponding to lactate threshold. The participants used heart rate monitors (Polar Electro, Finland) to control intensity.

Statistical analysis

We performed statistics with SPSS 19 (Statistical Package for Social Science, Chicago, USA). We presented data as mean ± standard deviation (SD). To evaluate significance of differences measured in the training sessions on different days we used ANOVA with repeated measures. We considered a two-tailed $P < 0.05$ significant for all tests. To investigate the magnitude of the effect, effect size (ES) was calculated in the form of Cohen's d (Cumming 2012) for outcome variables. Effect size of 0.2 is regarded small, 0.5 medium and 0.8 large (Cumming 2012).

RESULTS

Table 2. Shows the results of all measured data during the subjective feeling controlled training session and the non-blinded HR controlled training.

Mean speed during the session at LT is significantly larger in the non-blinded HR controlled session compared to the blinded subjective controlled session (ES, 0.61; $P = 0.04$). In addition, distance covered is significantly larger in the non-blinded session (ES, 0.63; $P = 0.04$) (Table 2.).

The result shows that the participants start the first ten minutes of the training session at a lower intensity when blinded compared to using HR monitors (ES, 0.98; P = 0.05) (table 2. and Figure 1.). During the session the registrations at 20 and 30 minutes shows that participants gradually tune in to the right intensity, and the differences between blinded and non-blinded sessions get smaller and non-significant (table 2. and Figure 1.). The participants perceive the blinded session as easier than the non-blinded session (ES, 0.88, non-significant) through Borg scale rating of perceived exertion (table 2.).

Table 2. Results from the training sessions

	Blinded (n = 8)	**CI**	**Heart rate monitors (n = 8)**	**CI**	**Effect size**	**P value**
HR						
Varm-up values	135.7 ± 24.1	113.5 , 157.9	136.9 ± 20.4	118.0 , 155.7	0.05	0.82
10 minutes	159.0 ± 15.7	144.5 , 173.6	170.7 ± 6.2	165.0 , 176.5	0.98	0.05*
20 minutes	168.6 ± 12.9	156.56 , 180.58	174.4 ± 9.4	165.71 , 183.15	0.52	0.14
30 minutes	173.9 ± 12.7	162.13 , 185.59	178.0 ± 9.1	169.59 , 186.41	0.38	0.38
$[La^-]_b$						
Varm-up values	2.01 ± 1.04	1.05 , 2.98	1.96 ± 0.85	1.17 , 2.74	0.05	0.91
10 minutes	2.23 ± 0.84	1.45 , 3.01	3.24 ± 1.26	2.08 , 4.41	0.94	0.06
20 minutes	3.06 ± 2.07	1.15 , 4.97	4.14 ± 1.63	2.63 , 5.65	0.59	0.20
30 minutes	3.83 ± 2.48	1.53 , 6.13	4.34 ± 1.47	2.98 , 5.70	0.25	0.55
Speed (km/h)						
Varm-up values	5.6 ± 1.5	4.01, 7.16	5.7 ± 1.9	3.72 , 7.61	0.06	0.88
10 minutes	6.6 ± 1.2	5.54 , 7.72	7.6 ± 1.4	6.36 , 8.90	0.78	0.05*
20 minutes	6.8 ± 1.4	5.52 , 8.05	7.5 ± 1.3	6.22 , 8.69	0.50	0.06
30 minutes	6.8 ± 1.7	5.30 , 8.39	7.5 ± 1.3	6.33 , 8.35	0.44	0.11
Borg	13.57 ± 0.98	12.67 , 14.47	14.43 ± 0.98	13.53 , 15.33	0.88	0.08
Mean speed during LT session	6.75 ± 1.38	5.48, 8.03	7.56 ± 1.26	6.40 , 8.72	0.61	0.04*
Distance covered (Km)	3.36 ± 0.71	2.71 , 4.02	3.78 ± 0.63	3.20 , 4.36	0.63	0.04*

Data is presented as mean ± SD. * Significant differences between training sessions (P<0.05).

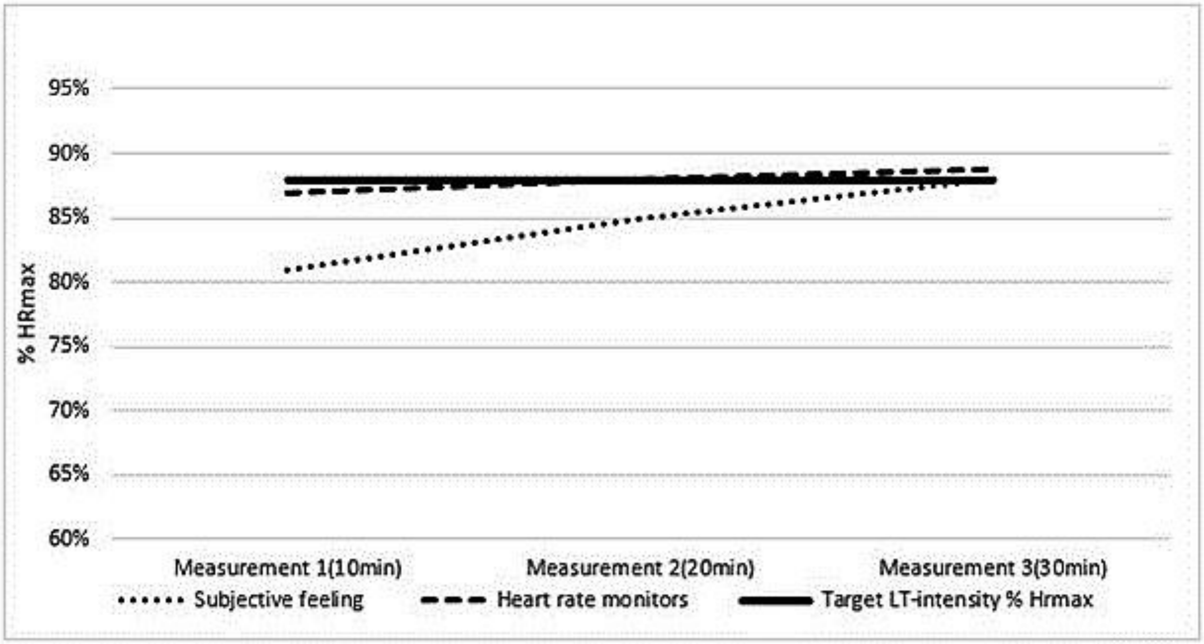

Figure 1. Shows mean % HR_{max} during the training sessions. The solid line marks the target intensity at LT.

DISCUSSION

The main finding of the present study is that the use of HR monitors is a more precise method to control exercise intensity than using subjective feeling. When using subjective feeling, the participants starts the training at significantly lower intensity the first ten minutes (ES, 0.98; P = 0.05), then participants gradually tune in to the LT-intensity from 20 to 30 minutes ES is moderate and small and non-significant. The differences are reflected through lower HR, $[La^-]_b$, and speed (Table 2.). The mean speed and distance covered is significantly smaller, ES 0.61 and 0.63 respectively (table 2.), during the training session controlling intensity through subjective feeling compared to using HR monitors.

Perceived exertion is previously shown to correlate well with HR-measurements in regulation of exercise intensity (Foster et al. 2001a). Further, Fabre et al. (2013) found rating of perceived exertion (Borg CR100 scale) to coincide well with LT. Our data only partially support this finding. Although the athletes in the present study are familiar with training at LT, they use a large part of the training session to reach an intensity close to LT. Not until the last ten minutes, they approach the LT-intensity. However, when using HR monitors the athletes reach their target intensity during the first ten minutes, and they manage to keep this intensity throughout the training session (Figure 1.). This underestimation of intensity coincides with Foster et al. (2001b), reporting that less experienced athletes tend to underestimate hard training sessions. Other studies examining self-regulation of exercise intensity report training slightly below LT as preferred intensity (Ekkekakis 2009; Rose and Parfitt 2010), probably driven by intuition to maximize pleasure or minimize displeasure (Ekkekakis 2009).

Although not significant, the effect size is large between subjective regulation and HR controlled in self-perceived exertion (Borg) (table 2.). Values of 13-14 is classified as “somewhat hard” while values of 15-16 is classified as “hard” (Borg 1982). Both 13.6 perceived in the subjective controlled session and 14.4

perceived in the heart rate controlled session classifies within “somewhat hard”, but the heart rate controlled session is in the upper part of the scale and approaching “hard”. This coincides well with Ekkekakis (2009) and (Rose and Parfitt 2010). Previously, Feriche et al. (1998) reported values between 12-13 to correlate well with ventilatory threshold. In the present study, training sessions perceives above 13 in the subjective controlled session, and 14.4 in the HR monitor session corresponding to HR at LT.

Lactate threshold, and in particular, speed at LT is a strong determinant of endurance performance (Bassett and Howley 2000; Grant et al. 1997; McLaughlin et al. 2010; Yoshida et al. 1993). This study demonstrates that underestimating intensity at LT result in significantly lower speed at LT and distance covered during the training sessions (Table 2.). This have a direct impact on performance. Moreover, considering the large amount of training conducted by this group of athletes, this would likely have large impact on their total performance during the season. Development of good work economy depend on total work performed, rather than exercise intensity (Helgerud et al. 2007). Underestimation of training intensity lead to less total work performed, and thus a smaller effect on work economy. However, due to small amounts of training conducted at LT-intensity (Seiler and Kjerland 2006) not recognizing LT-intensity in competition may be more crucial. A mean difference of 0.81 Km/h is significant (P = 0.04) and meaningful (ES = 0.88) (Table 2.). In the present study, the athletes cover a substantially larger distance, 0.42 Km, regulating intensity with heart rate monitors compared to subjective feeling (table 2.). Although polarized training with little training time spent at LT seem to be beneficial in adult endurance athletes (Esteve-Lanao et al. 2007), young athletes that are more inexperienced may need more training time spent at LT-intensity to learn controlling intensity during competition. In biathlon, performance not only depend on the racing speed, they must also control intensity, i.e. down regulate HR, to perform in rifle shooting at the shooting range (Coote 2010). Thus, learning to control HR is likely particularly important for biathletes.

There is evidence of a mismatch between coaches training programs and the training executed by the athletes. Athletes perform Hard training sessions lighter and light training sessions harder than intended (Foster et al. 2001b). We do not know the reason of this mismatch, however, our findings suggest that using heart rate monitors rather than, or at least in addition, to subjective feeling gives better intensity control. In accordance with (Foster et al. 2001b), the athletes underestimate intensity in the present study when regulating intensity by subjective feeling. It is important that athletes execute the training program designed by coaches for several reasons. First, to gain optimal adaptions from endurance training, keeping intensity low in the low intensity sessions and high in the high intensity sessions is important since combined training programmes seem to give larger adaptions than high or low intensity programs separately (Laursen 2010). In particular executing a large amount of training at moderate intensity seem to be counterproductive (Esteve-Lanao et al. 2007). Secondly, in order to maintain the necessary amount of training to enhance performance, regulating training intensity seem important to avoid overtraining (Foster 1998). Variation between hard and light training days seem to give less strain than monotonous training. For instance, four days with hard training with two light days between and on day off, gives less strain than 6 days with less severe hard days with one day off (Foster 1998). HR monitors will likely serve as a useful learning tool in recognizing the sensation of various intensities. This should be further investigated in intervention studies. Finally, registrations of HR during training sessions will be useful to adjust training plans to assure optimal effect from endurance training. Using HR monitors give the opportunity to control intensity during the season, and serves as a reliable tool in evaluation of training plans.

CONCLUSIONS

We conclude that using heart rate monitors provide a better control of intensity in young biathletes than using subjective feeling to control exercise intensity. Using subjective feeling underestimate intensity at lactate threshold, and results in significantly, lower distance covered. In combination with subjective feeling, use of HR monitors can help junior athletes controlling training intensity, and secure that executed training is in accordance with the training planned by coaches. Recognizing different training intensity might be difficult for inexperienced athletes. Use of HR monitors will secure that target intensity is held.

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