TITLE PAGE

Effects of age, sex, sweat rate and environmental conditions on heart rate and perceived exertion in indoor cycling

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ABSTRACT

BACKGROUND: Indoor cycling sessions are usually guided by heart rate (HR) and rating of perceived exertion (RPE). This study was designed to examine the effects of sex, age, previous experience, use of a HR monitor, estimated sweat rate and room temperature and humidity increases on HR and RPE during indoor cycling sessions. METHODS: Measurements were made in 39 sessions performed by 300 experienced subjects. Sweat rate was categorized as SR1 ≥ 750, SR2 = 400-749 and SR3 < 400 ml; temperature increase as T1 ≤ 0.2, T2 = 0.2°C-1.5 and T3 > 1.5°C; and humidity as H1 ≤ 2, H2 = 2-15 and H3 > 15 percentage points. Mean HR was determined for the sessions and RPE recorded at the start, middle and end of each session.

RESULTS: Significant differences in HR were observed between SR1 and SR3 (148.22 ± 12.17 vs 141.73 ± 17.39 bpm; $p<0.05$) and between T1 and T2 (141.01 ± 16.38 vs 146.95 ± 15.29 bpm; $p<0.05$). The RPE was lower ($p<0.05$) for T1 than T2 or T3 in all recordings and for H1 than H2 or H3 at the session start and middle.

CONCLUSION: Our results indicate that real (%HRmax) and perceived (RPE) intensity of exercise in an indoor cycling session are influenced by factors such as the estimated sweat rate, or the increase in temperature or relative humidity produced in the cycling room.

KEYWORDS

Spinning, cycling endurance, environmental conditions, exercise in hot, sweat loss.

INTRODUCTION

Indoor cycling is a popular sport performed as a group activity in fitness centres by individuals of varying age and physical condition. Indoor cycling consists of interval cardiovascular training conducted on a static bicycle to the rhythm of music. Training intensity is usually guided by heart rate (HR) and/or subjective perceived exertion (RPE) [1].

Prior findings have indicated the extremely high training intensity of indoor cycling, which may be even comparable to the work intensity of aerobic resistance training in elite athletes [2]. Several studies have examined HR or RPE responses in indoor cycling sessions both in laboratory settings [3,4] and in real sessions [5,6]. Our group has recently reported the results of such responses determined in the largest study conducted so far on indoor cycling in real conditions [7].

Controlling the intensity of exercise in indoor cycling can be difficult because of the many variables involved such as participant profiles or the training characteristics which may affect commonly used indicators of intensity such as HR and/or RPE [8-11].

Indoor cycling (IC) is an activity practiced in fitness centers by a large number of users of both sexes with different age ranges and level of experience. As an indoor activity, the room´s environmental variables could influence the HR response and the RPE, making it difficult to control the intensity during the training sessions. Some studies have analyzed the mechanisms by which HR and RPE may be altered during exercise [9-14], although to date, there is no study that specifically focuses on the variables that may influence the HR response and the RPE during IC. Some laboratory studies have already observed that trained subjects pedaling at high temperatures (35º C) achieved higher HR values than other subjects doing so at a lower temperature (22ºC)[11]. The ambient temperature could also alter the RPE response; for example, cyclist pedaling during 60 mins in a hot enviroment (30º) reported higher RPE values than those in a cooler enviroment (18ºC); these differences increasing from the second 30 mins[12]. The rate of sweating may also be related to a change in the HR response during exercise; review studies[15] have corroborated that a dehydrated state (loss >2% of body mass) can reduce the athlete´s aerobic performance, especially when dehydration is also ocurring in a hot enviroment, with an increase in HR and a decrease in SV. IC is an activity with participants achieving high rates of sweating, so the appearance of a being in a dehydration state is frecuent. Other enviromental variables such as humidity could affect the HR and RPE. In a study with 8 subjects pedaling at 70% of their max VO2 at different levels of relative humidity, higher values of HR and RPE were observed when humidity was higher[14].

The present study was designed to examine the effects of sex, age, previous experience, habitual HR monitoring, estimated sweat rate and increases in temperature and humidity produced in the training room on HR and RPE responses during several standardized indoor cycling sessions in a large population of healthy men and women with considerable experience in this exercise modality.

MATERIAL AND METHODS

Thirty nine indoor cycling sessions at 8 fitness centres guided by 16 instructors were monitored. Sessions were performed in the same conditions as usual for each centre at the usual times and directed by the usual instructors. The methods used in the sessions were unmodified. The mean participation rate was 7.71 ± 3.43 subjects per session and mean session duration was 46.46 ± 2.41 minutes. During the sessions, participants received no information about their HR.

The study participants were 300 healthy and physically active adult volunteers (184 men, 116 women) with experience in indoor cycling (3.60 ± 3.32 years), participating in IC sessions at least 2 times per week during the last year. The largest number of possible participants, meeting the said criteria, were selected from the fitness centres where the IC sessions were held.

The main training and biometric characteristics of the study participants are provided in Table 1. Subjects were requested to refrain from ingesting caffeine or any other stimulant in the 3 h prior to a monitored session, and they also refrained from physical exercise in the 24 h leading to the study outset. Each participant provided written informed consent. The study protocol was approved by the Ethics Committee of the Universidad Complutense de Madrid.

Before and after each indoor cycling session, subjects were weighed on a Seca 784 balance (Hamburgh, Germany) in their underwear. Each subject's drinking water bottle was also weighed using a precision balance (Baxtran bat 1500, Girona, Spain) before and after each session. The sweat rate was estimated as the sum of the differences recorded in body weight and water bottle weight [(Subject´s weight pre – subject´s weight post) + (bottle weight pre – bottle weight post)][12,16]. Water intake during each session was *ad libitum*.

Room temperature (°C) and humidity (%) were measured before and after each session using a validated meteorological station (Oregon Scientific Bar 806, Portland, Oregon, USA).

Maximum theoretical heart rate (HRmax) was determined using the equation “220 minus age”[17]. During the exercise sessions, HR was recorded from the time individuals started pedalling to when the instructor indicated the end of the session. HR was not measured during the final muscle stretches. A telemetric system was used (Suunto Team Pod, Vantaa, Finland) to record mean HR for the entire session.

Also recorded was each subject's perceived exertion (RPE) using Robertson's OMNI scale [18] specifically validated for bicycle exercise. Participants were instructed to use the OMNI scale correctly prior to the session. An investigator explained in detail the relationship between the perception of effort and the graphical and numerical description of the scale, following the protocol stablished for its use[18]. We recorded RPE scores in minutes 15 (RPE1) and 30 (RPE2) of the session, and in minute 45 at the end of the main part of the session (RPE3). Subjects noted their RPE while continuing to pedal.

For statistical analysis of the data, participants were stratified by: 1) sex (men, women); 2) age (Age1 ≤ 35 years, Age2 = 36 to 45 years, Age3 > 45 years); 3) experience with indoor cycling, starting from the uninterrupted time since subjects began to practice IC at least 2 days per week (Exp1 ≤ 1 year, Exp2 = 2-4 years, Exp3 ≥ 5 years); 4) use or not of a heart rate monitor over the preceding 6 months (pulsometerYES, pulsometerNO); 5) sweat rate (SR1 ≥ 750 ml, SR2 = 400 to 749 ml, SR3 < 400 ml); 6) room temperature increase during the session (T1 ≤ 0.2°C, T2 = 0.2°C to 1.5°C, T3 > 1.5°C); and 7) room humidity increase during the session (H1 ≤ 2 percentage points, H2 = 2 to 15 percentage points, H3 > 15 percentage points).

For quantitative variables, subjects were divided into quartiles. Individuals comprising quartiles 2 and 3 were assigned to the intermediate group.

Statistical tests were performed using the program SPSS 19.0 for Windows. Means for quantitative variables were determined through descriptive statistics and compared via the Student's t-test. The Levene test was used to confirm equal variances considering differences significant when $p<0.05$. For variables defined as three groups, an ANOVA test was used to compare means and the Duncan test was used for pairwise comparisons. Significance was set at $p<0.05$.

RESULTS

Mean exercise intensity expressed as the relative (%HRmax) or absolute (beats per minute, bpm) heart rate for the 39 sessions recorded for the 300 subjects was 80.95 ± 8.30% or 144.84 ± 15.59 bpm, respectively. Mean HR during the session based on gender, age, experience and use of the heart rate monitor are shown in table 2, while the mean HR values based on estimated sweat rate, temperature increase and humidity increase are shown in table 3.

Mean ratings of perceived exertion for the different time points in the 39 sessions were 5.39 ± 1.72 for RPE1, 7.14 ± 1.34 for RPE2, and 7.14 ± 2.44 for RPE3. RPE values during the session based on gender, age, experience and use of the heart rate monitor are shown in table 4, while RPE values based on estimated sweating rate, temperature increase and humidity increase are shown in table 5.

DISCUSSION

The main findings of our study were that the intensity of exercise performed and perceived in standard indoor cycling sessions was affected by the estimated sweat rate and by temperature and humidity increases produced in the room where the sessions were undertaken. Other variables such as age, sex, experience and habitual use of a HR monitor had no significant effects on the HR and RPE responses recorded during the sessions.

Although other studies have already observed that enviromental variables such as temperature and humidity could alter the HR response and RPE during exercise (references), this is the first study to measure this influence specifically during an IC session out of a laboratory, in a real life situation. When performed in a closed indoor space, the IC is an activity in which the control of temperature and humidity is important for an adequate control of the intensity of exercise.

Room temperature increase affected the HR response though significant differences were only detected between groups T1 and T2, indicating that individuals undertaking indoor cycling when a lower temperature increase was produced in the room during exercise showed lower mean HR values. This effect could be attributed to cardiac drift, or the progressive increase in HR accompanied by a decrease in systolic volume that occurs during long-duration moderate exercise [10,19]. Several factors have been implicated in cardiac drift, though the findings of most studies indicate that core body and skin temperature are determining factors [9,10,15]. Other studies have shown that training in conditions of heat can have the consequence of an increased heart rate [11,12] reducing resistance exercise performance [20].

In this study, subjects undertaking indoor cycling sessions in which a lower intrasession increase in room temperature was produced were also observed to show significantly lower RPE scores. Other authors have confirmed the relationship between a warm training environment and elevated RPE ratings [21,12]. González-Alonso et al. (1999) [21] reported that 30 minutes of cooling down in a pool before exercise led to a lower RPE than when subjects warmed-up before exercise. In another study [12], higher RPE values were recorded when a constant exercise protocol on a cycle ergometer was performed at an ambient temperature of 30°C compared to 18°C. It therefore seems clear that hyperthermia affects the RPE response to exercise. Hence, before core temperature is elevated and only skin temperature is high, the subject seems to automatically select a lower work rate. In this case, the subject's heat perception will mainly affect the RPE. Subsequently, when both core and skin temperature rise it will be factors related to cardiovascular stress that will affect the RPE [22]. Another reason why heat stress affects RPE could be related to changes produced in motor neurone function and in brain waves [9]. Thus, some studies have shown RPE increases when conducting exercise in conditions of heat and correlation between core temperature, brain wave frequency and RPE, possibly relating changes in brain activity and fatigue in response to prolonged exercise in such conditions [13].

In the present study, when the intrasession humidity increase in the cycling room was lower, subjects reported lower RPE scores at the session start and in mid-session (RPE1 and RPE2). Others [14] have also indicated that humidity affects RPE in a study in which 8 subjects pedalled on a cycle ergometer at a constant intensity of 70%VO_2max until exhaustion. Subjects repeated this protocol four times at a constant temperature but at different relative humidity levels (24, 40, 60 and 80%). Finally, it was observed that RPE was significantly higher in the session performed at 80% relatively compared with 24%. As in our study, no significant effects of relative humidity were observed on the HR response.

Although age did show an effect on mean HR (bpm) this was mainly due to a physiological age-related attenuation in HR [23], and no effects were detected when HR was expressed in relative terms. This suggests that the age of the study participants did not affect the relative HR response in the indoor cycling sessions.

We also observed a similar HR response in men and women. In another study [4] neither were differences noted in the HR response in 6 men and 6 women who individually undertook an indoor cycling session in a laboratory. In contrast, other authors [5] did observe sex differences in mean HR after an indoor cycling session guided by an instructor. However, in this study, subjects spent 80% of the session time above the target intensity recommended by the instructor which could mean that exercise intensity control in the sessions monitored was not good. In a recent study performed on a large study population (n=749) no gender differences in HR were observed in subjects conducting cardiovascular exercise in a ramp protocol until volitional exhaustion both on a cycle ergometer and treadmill [24].

Previous experience in indoor cycling had no effect on the HR or RPE scores recorded during the sessions. Neither were differences detected in the mean HR response to aerobic and step exercise [25], both in absolute (bpm) and relative (%HRmax) terms according to the experience of two groups of female participants. However, the authors mentioned that individuals in the less experienced group found it more difficult to control their target HR at each stage in the session.

In the present study we also observed that the RPE response was not conditioned by the prior experience of the participants. Other authors [26] reported greater correlation between RPE and HR after five familiarization sessions using the Borg scale (6-20). Our study population had much experience in indoor cycling and it did not seem that knowledge of the use of the RPE scale affected the scores awarded. The RPE scores reported by other authors for indoor cycling are similar to our values despite the participants of these studies having less experience than the present subjects [2,6,27]. For example, Battista et al. (2008) [2] in a sample comprised of subjects whose experience was at least of two weekly sessions in the preceding two months, recorded an RPE of 5 to 8 points depending on the session stage. Miñarro and Muyor (2009) [6] in a sample of 59 subjects with 4 to 12 weeks of experience obtained an RPE of 14.2±1.8 points, which on a scale of 1-10 would be equivalent to 7-8 points. Finally, Muyor (2013) [27] recorded in 53 subjects who undertook indoor cycling 3 days per week during the 3 months before the study an RPE of 7.18±0.79 points. These RPE scores are consistent with those observed here even if we consider scores awarded by our group of 72 subjects who had been indoor cycling for 5 years (5.16±1.81 points at the session start, 7.27±1.35 at mid-session and 6.70±2.77 at the session end).

With respect to the use of a HR monitor, no differences in mean HR were detected for the complete session. However, we did note a higher mid-session RPE (RPE2) score awarded by the subjects that habitually used a pulsometer when training. It is likely that these subjects achieved better control of their training load, though the lack of differences in HR values and the absence of previous data on this issue make it difficult to adequately interpret these findings.

CONCLUSIONS

In summary, our findings indicate that the intensity of exercise achieved (HR) and perceived (RPE) in standard indoor cycling sessions is affected by sweat rate and the increases in ambient temperature and humidity produced during the cycling sessions. Other variables such as age, sex, experience and habitual use of a HR monitor do not seem to substantially impact HR and RPE responses to indoor cycling.

HR and RPE monitoring are effective tools to guide training intensity in sessions of indoor cycling. However, instructors also need to control any variables that could influence HR and RPE responses. This means ensuring optimal temperature and humidity conditions in the cycling room along with the adequate hydration of the subjects. These factors emerged here as key to guarantee the adequate use of HR and RPE to effectively guide the training load in indoor cycling sessions.

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TABLES