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Title: Effects of Two Types of Distractions on the Ratings of Perceived Exertion and Affective Responses during Acute High-intensity Cycling Exercise for fair cardiorespiratory fitness level men.

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Running title: Effects of Distractions on RPE and Affects during High-intensity Exercise

Abstract

This study examined the effects of distractions on ratings of perceived exertion (RPE) and affective responses during acute high intensity cycling exercises. Eighteen young males (age: 22.2±1.7 years) visited the laboratory on four sessions. Participants performed three experimental trials following an incremental maximal test. During the three trials, participants performed cycling exercises at 70% $\dot{V}_{O_2max}$ for 20 min under three conditions: control, active distraction, and involuntary distraction. The participants rated their overall and peripheral RPE at 5 min intervals during the 20 min cycling period. Participants' affective responses were assessed before and after cycling including positive engagement (PE), negative affect (N-affect), and tranquility. There were no significant differences in RPEs among the three conditions. For affective responses, a significant main effect of condition was seen only for N-affect. This study suggested that active and involuntary distractions do not influence perceived exertion when participants perform 20-min vigorous-intensity exercises. One possible reason for the result is that inadequate method used as active distraction. Further research is required to examine the appropriate methods that promote distraction from bodily sensations during high-intensity exercise.

Keywords: active distraction, involuntary distraction, RPE, Waseda Affect Scale of Exercise and Durable Activity

日本語タイトル：2 種類の分離的方略の使用が，一過性の高強度サイクリング運動に伴う自覚的運動強度と感情反応に及ぼす影響.

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日本語抄録：本研究は，外部注意方略が一過性の高強度サイクリング運動中の自覚的運動強度（RPE）と感情反応に及ぼす影響について検討することを目的とした．18 人の健常男性（年齢：22.2±1.7 歳）を対象とした．対象者は，漸増負荷試験実施後，3 回の実験試行を行った．3 回の実験試行では，対象者は，コントロール条件，能動的外部注意条件，非能動的外部注意条件の 3 つの条件下で，70% $\dot{V}_{O2max}$ のサイクリング運動を 20 分間行った．20 分間のサイクリング運動中，対象者は 5 分間隔で全体的な RPE，脚部の RPE を評価した．また，サイクリング運動実施前後に感情反応（高揚感，否定的感情，落ち着き感）を評価した．統計解析の結果，3 つの条件間で両 RPE に有意な差は認められなかった．感情反応については，否定的感情において有意な条件の主効果が認められたが，高揚感，落ち着き感には有意な条件の主効果は認められなかった．今回の結果は，20 分間の高強度運動を実施する際には，能動的外部注意，受動的外部注意のどちらを用いても自覚的運動強度が変化しないことを示唆している．今後，高強度運動において身体感覚から注意を逸らす適切な方法を検討する必要がある.

Introduction

Adequate exercise volume is required to promote and maintain health; however, excessive perceived exertion inhibits exercise behavior. Perceived exertion and positive affective responses are influenced by attentional focus [1-2]. However, several studies on attentional focus during aerobic exercise did not include adequate exercise volume required to promote health. To demonstrate the effectiveness of attentional focus, research should be conducted using sufficient exercise volume to promote health.

Exercise intensity above moderate and of adequate duration is important for improving and maintaining health status. The American College of Sports Medicine [3] recommends moderate-intensity (46–63% maximal oxygen uptake [$\dot{V}O_{2max}$]) aerobic exercise for a minimum of 30-min or vigorous-intensity (64–90% $\dot{V}O_{2max}$) aerobic exercise for a minimum of 20-min to promote and maintain health. Moderate-to-vigorous intensity exercises have been shown to be effective in improving cardiorespiratory fitness for cardiac rehabilitation [4]. Both 20-min and 40-min moderate (60% heart rate reserve [HRR]) and vigorous (80% HRR) exercise increases brain-derived neurotrophic factor [5]. Therefore, adequate exercise volume is needed to improve and maintain health. However, increasing the exercise intensity and longer exercise duration leads to enhanced perceived exertion.

Several studies have suggested that focusing on bodily sensations increases ratings of perceived exertion (RPE), whereas distracting attention from bodily sensations decreases RPE and increases positive affective responses [1-2]. A pioneering study by Morgan and Pollock [6] introduced an elite distance runner's cognition of association and dissociation. Association refers to paying attention to bodily sensations, while dissociation refers to distracting attention from bodily sensations. Stevinson and Biddle [7] proposed two-dimensional classification of inward monitoring, outward monitoring, inward distraction, and outward distraction. In addition, Brick et al. [2] proposed a new model of attentional focus of internal sensory monitoring, active self-regulation, outward monitoring, active distraction, and involuntary distraction. Internal sensory monitoring may cause an increase in perceived exertion [8-10], whereas active and involuntary distraction may cause a decrease in perceived exertion [8, 10-11]. Moreover, involuntary distraction may positively influence mood changes [12-13] and exercise adherence [14]. Based on the parallel processing model [15], intentional distraction from bodily sensations might decrease perceived exertion more than non-intentional distraction. Therefore, active distraction during aerobic exercise may result in lower perceived exertion than involuntary distraction. However, no studies have examined the effects of distraction (active/involuntary) on perceived exertion or affective responses.

Moderate-to-vigorous exercise intensity and adequate exercise duration are required to demonstrate the effectiveness of active and involuntary distractions during exercise for improving health. For example, Schücker et al. [16] and Neumann and Piercy [17] adopted a 6-min run, but this exercise duration was too short for the time recommended by the ASCM [3]. Johnson and Siegel [9] reported that participants in the dissociation group rated lower RPE than in the association group during a 15-min cycling task at 60%$\dot{V}O_{2max}$. Furthermore, RPE during a 10-min cycling task at 75%$\dot{V}O_{2max}$ was significantly lower in the dissociation than in the association [10]. Even in studies suggesting the effect of distraction on RPE [9-10], the exercise duration was insufficient to maintain or improve health. Therefore, an adequate exercise duration is necessary to examine the effectiveness of distraction on perceived exertion.

An exercise intensity that allows a clear perception of physical exertion is necessary to examine the effect of distraction on perceived exertion during exercise. Perceived exertion increases exponentially with increasing exercise intensity [18], i.e., changes in subjective bodily sensations such as fatigue and pain, may be perceived less at lower exercise intensity than at moderate and higher exercise intensity. Given the nature of the perception of exercise intensity, high intensity exercise, in which participants can clearly perceive their exertion, should be performed to examine the effect of distraction on perceived exertion. Hayashi et al. [19] suggested that perception of exercise intensity may be more precise after performing 5-min cycling at 70%$\dot{V}O_{2max}$. Robertson [20] proposed that exercise above 70%$\dot{V}O_{2max}$ may incur a painful or unpleasant sensation. Therefore, the perception of physical exertion may be inaccurate when the exercise intensity is below 70%$\dot{V}O_{2max}$.

Given the afore-mentioned findings, our study aimed to examine the effects of distractions (active and involuntary) on perceived exertion during a 20-min exercise at 70%$\dot{V}O_{2max}$. This exercise duration is adequate to maintain and improve health, and the exercise intensity is assumed to clearly indicate physical exertion. Our study also aimed to examine the effects of the distractions (active and involuntary) on affective responses. Some studies have reported that involuntary distraction evokes positive mood change [12-13]. Examining the effects of differential distraction on perceived exertion and affective responses during a 20-min exercise at vigorous intensity, the effectiveness of distractions for exercise programs or exercise prescriptions might be suggested. We hypothesized that active distraction would decrease the RPE more than involuntary distraction (H_1). We also hypothesized that involuntary distraction would have a more positive effect on affective responses than active distraction (H_2).

Material and Methods

Participants

Eighteen healthy males (age: 22.2 ± 1.7 years, height: 170.8 ± 6.0 cm, weight: 67.3 ± 9.9 kg, %fat: 16.7 ± 6.5 %, $\dot{V}O_{2max}$: 42.5 ± 7.0 mL/min/kg) participated in this study. According to the questionnaire about the physical activity stages of change [21], 4 participants were in the preparation stage, 2 in the action stage, and 12 in the maintenance stage. In a previous study examining the standard values of cardiorespiratory fitness in 367 men aged 20-29 years [22], a $\dot{V}O_{2peak}$ of 42.8 mLO_2/kg/min belonged to the 40-50 percentiles. Therefore, the aerobic capacity of the participants in this study can be considered as being of ‘fair level’. All participants provided informed consent before participation. This study was approved by the Research Ethics Committee of the Graduate School of Sports and Health Studies, Hosei University (approval number: 2022–12).

Measurements

In our study, two types of perceived exertion (overall and peripheral RPE), affective responses, respiratory parameters, and heart rate (HR) were measured. Overall and peripheral perceived exertion (RPEover and RPEperi) were assessed using the Japanese scale for Rating Perceived Exertion [20]. For RPEover, the experimenter asked the participants to honestly indicate the overall physical exertion. For RPEperi, the participants were asked to honestly indicate the perceived exertion of their legs. Affective responses were measured using the Waseda Affect Scale of Exercise and Durable Activity (WASEDA) [21]. It consists of 12 items that measure positive engagement (PE), negative affect (N-affect), and tranquility.

Procedures

The participants visited the laboratory for four sessions. In the first session, the participants provided informed consent and their body composition and height were measured. After these measurements, the participants completed an incremental cycling test (ICT) to volitional exhaustion to assess their aerobic capacity. In the following three sessions, the participants performed experimental trials under three different conditions: control (no specific instructions), active distraction, and involuntary distraction.

Incremental cycling test protocol

The participants completed an ICT to volitional exhaustion on an electromagnetically stationary cycle ergometer (AEROBIKE 75XLII, COMBI) to assess their aerobic capacity. The workload was increased by 14 or 16 Watt (W) every minute (30 W every 2-min) after a 1-min warm-up at 30 W. The workload could only be changed manually by 2 W; therefore, the workload was calibrated by 2 W. Respiratory data and HR were measured using a respiratory gas analyzer (POWERMETS, AT-1100A, ANIMA) and a chest HR monitor (T31C, Polar) throughout the ICT.

Participants $\dot{V}O_{2max}$ was determined based on two out of the following three criteria being met [25]: 1) a plateau in $\dot{V}O_2$ (< 150mL/min) despite exercise intensity increase, 2) respiratory exchange ratio more than 1.10, and 3) HR reaching 90% of maximal HR

(HRmax; 206.9 − (0.67 × age)). The HRmax was calculated using the method described by Gellish et al. [26]. $\dot{V}O_{2peak}$ was used as the $\dot{V}O_{2max}$ if none of the criteria were met. Eight participants did not meet the above criteria; therefore, $\dot{V}O_{2peak}$ was used as $\dot{V}O_{2max}$. From the $\dot{V}O_{2max}$ data, the workloads corresponding to 35% and 70% $\dot{V}O_{2max}$ (35% and 70% W_{max}) for each participant were calculated and used for the subsequent experimental trials.

Experimental trials

After ICT, three experimental cycling tasks were conducted as follows. The cycling task comprised a 5-min warm-up at 35% W_{max}, 20-min cycling at 70% W_{max} (main task), and 5-min cool down. This exercise volume fulfills the ACSM-recommended exercise volume and improves glucose utilization [27] and $\dot{V}O_{2max}$ [28]. Participants were told the attentional instructions before each trial and asked to maintain their attention as instructed during the task. The respiratory data and HR were measured during the task using the same ICT apparatus. The RPEover and RPEperi were measured every 5-min during the main task. Affective responses were measured using WASEDA before and after cycling. The participants could freely determine their cadence in the range of 55 to 65 rpm during the task. The bicycle ergometer used in the experiment automatically adjusted the resistance such that the workload remained constant, even when the pedaling rate changed. The order of the conditions was random and all sessions were separated by at least 24h.

We tried to minimize participants attention to the pedaling rate to prevent interference with the intended attentional focus in each condition. Previous studies have reported that pedaling rate changes oxygen uptake [29-31)] and perceived exertion [29, 32, 33)], and the pedaling rate should not be changed. However, attention to the pedaling rate may interfere with the intended attentional focus in each condition. In a previous study comparing oxygen uptake during a 5-min cycling exercise in non-cyclists at five pedaling speeds (45, 60, 75, 90, and 105 rpm) at 150 W and 200 W, no significant differences were found in oxygen uptake at 45, 60, and 75 rpm under both loads [31)]. Further, no significant differences were found in oxygen uptake during 5-min cycling at 70% $\dot{V}O_{2max}$ between 40 and 60rpm, and 60 and 80rpm [29)]. Further, no significant differences were found in the oxygen uptake during 15-min of cycling at constant loads between 40, 50, 60 rpm, and 60 and 70rpm [30)]. Considering these studies on oxygen uptake, $\dot{V}O_2$ may not change significantly for differences below 10 rpm. For perceived exertion, a significant difference was found in RPE during 5-min cycling at 70% $\dot{V}O_{2max}$ between 40 and 60rpm [29)]. Significant differences were found in leg RPE, chest RPE, and overall RPE at 40 and 60 rpm, and 40 and 80 rpm under 140 W 6-min cycling [32)]. Given the results of these studies on RPE, a 20 rpm difference in pedaling rate may affect RPE during cycling exercise. Given the influence of pedaling frequency on $\dot{V}O_2$ and perceived exertion during cycling, the pedaling rate of the experimental trials was freely selected within a range of 55 to 65 rpm, as changes in the pedaling rate within 10 rpm were judged to have no effect on $\dot{V}O_2$ or perceived exertion. In this manner, we attempted to minimize the participants' attention to the pedaling rate.

Attentional Instruction

In our study, based on Brick et al., two types of distractions were selected [2)]. That study introduced a new categorization of attentional focus including internal sensory monitoring, outward monitoring, active self-regulation, and active and involuntary distractions. In our study, we focused on the effects of two types of distractions.

Active distraction (AD): In the AD condition, participants were asked to listen to four songs and count the number of times specific words were heard. The specific words were "BOKU" and "KIMI" (which means "I" and "You" in English). The participants answered the sum of these words immediately after RPE measurement. The durations of the songs were 3:55, 4:48, 5:00, and 4:36 min. The songs were played randomly every 5-min during the main task. The words "BOKU" and "KIMI" appeared a total of 11 times during the main task. Participants could *intentionally* distract their attention from bodily sensations by counting words.

Involuntary distraction (ID): In the ID condition, participants were asked to cycle as they usually do while playing songs. Unlike the AD condition, in the ID condition participants were not given specific instructions regarding songs; therefore, they were not asked to count specific words. The songs were identical to those used in the AD condition.

Statistical analysis

% $\dot{V}_{O2max}$ and % HR_{max} in every minute during main task were calculated to confirm the exercise intensity in each condition. Given that $\dot{V}_E$ and respiratory rate (RR) both variables may influence RPE [34)], both variables were calculated for every minute during the main task. Two-way (condition × time) repeated-measures ANOVA was conducted to analyze % $\dot{V}_{O2max}$ and % HR_{max} under the three conditions. The time measured in the analysis was 20-min, excluding the warm-up time. A linear mixed model with compound symmetry was used to examine the effect of the conditions on $\dot{V}_E$, RR, RPEover, RPEperi, and each affective response (PE, N-affect, and tranquility). Each condition, measurement time, and interaction were set as fixed effects and individual differences were set as random effect. All statistical analyses were performed using IBM SPSS Statistics ver. 29.0 (IBM, Armonk, NY, USA). A *post hoc* analysis was conducted using Bonferroni adjustment if significant main effects and interactions were observed. The significance level for all comparisons was set at $P < 0.05$. Data are presented as means and standard deviations.

Results

The accuracy of word count in AD condition

Regarding the number of occurrences of the words “BOKU” and “KIMI”, one participant each answered 5, 6, 8, and 10 times, four each answered 12 and 13 times, five answered 14 times, and one answered 15 times. None of the participants answered it correctly as 11 times.

% $\dot{V}O_{2max}$ and % HR_{max}

No significant main effect of condition (F [2, 34] = 1.75, $P = 0.19$) or interaction (F [38, 646] = 1.25, $P = 0.07$) was observed for % $\dot{V}O_{2max}$; however, a significant main effect of time was observed (F [19, 323] = 145.95, $P < 0.01$). Oxygen uptake increased with time until 6 min after the start of the main exercise, and then stabilized.

Similar to % $\dot{V}O_{2max}$, no significant main effects of condition (F [2, 34] = 0.47, P = 0.63) and interaction (F [38, 646] = 0.86, $P = 0.71$) were observed for % HR_{max}; however, a significant main effect of time was observed (F [19, 323] = 208.25, $P <$ 0.01). The HR increased with time until the end of the 20-min cycling exercise. ※ Table 1, 2 insertion.

$\dot{V}_E$ ***and RR***

No significant interaction (F [38, 1003] = 0.25, P = 1.00) was observed for $\dot{V}_E$, however, significant main effects of condition (F [2, 1003] = 17.15, P < 0.01) and time (F [19, 1003] = 123.90, P < 0.01) were observed. $\dot{V}_E$ in the control condition was significantly lower than that in the AD and ID conditions. For RR, no significant interaction (F [38, 1003] = 0.39, P = 1.00) was observed**;** however, significant main effects of condition (F [2, 1003] = 71.16, P < 0.01) and time (F [19, 1003] = 57.28, P < 0.01) were observed. RR in the control condition was significantly lower than that in the AD and ID conditions. The $\dot{V}_E$ and RR increased during cycling exercise under all conditions. ※ Table 3, 4 insertion.

RPEover and RPEperi

No significant main effect of condition (F [2, 187] = 0.23, P = 0.79) or interaction (F [6, 187] = 0.36, P = 0.91) was observed for RPEover; however, a significant main effect of time was observed (F [3, 187] = 32.39, P < 0.01). Similar to RPEover, no significant main effect of condition (F [2, 187] = 0.93, P = 0.40) or interaction (F [6, 187] = 0.85, P = 0.53) was observed for RPEperi; however, a significant main effect of time was observed (F [3, 187] = 29.22, P < 0.01). Both RPEs increased during cycling under all conditions. (Table 5). ※Tables 5 insertion.

Affective responses

No significant main effects of condition (F [2, 85] = 0.52, P = 0.60) or interaction (F [2, 85] = 0.07, P = 0.93) were observed for PE; however, a significant main effect of time was observed (F [1, 85] = 38.53, P < 0.01). PE significantly increased after the task. For the N-affect, significant main effects of condition (F [2, 85] = 4.19, P = 0.02) and time (F [1, 85] = 26.15, P < 0.01) were observed, but no significant interaction was observed (F [2, 85] = 0.30, P = 0.74). The N-affect in the AD condition was higher than that in the ID condition. In addition, N-affect significantly decreased after the task under all conditions. Unlike PE and N-affect, no significant main effect of condition (F [2, 85] = 0.80, P = 0.45), time (F [1, 85] = 1.66, P = 0.20), or interaction (F [2, 85] = 0.09, P = 0.91) were observed for tranquility (Table 6). ※Table 6 insertion

Discussion

The purpose of this study was to examine the effects of active and involuntary distractions on perceived exertion and affective responses during 20-min cycling at 70%$\dot{V}O_{2max}$. Our results suggest that both distractions may change the respiratory responses. On the other hand, our results suggest that both distractions do not influence perceived exertion and affective responses. One possible reason for these RPE results is that the method used for active distraction may have been inadequate. Our study has some limitations that warrant further investigation.

Our hypothesis (H_1) was rejected because there were no significant main effects or interaction effects for RPE. A previous study had reported that external focus was used more frequently than internal focus during a 50% $\dot{V}O_{2max}$ cycling, whereas external focus was used less frequently than internal focus during a 70% $\dot{V}O_{2max}$ cycling [35]. Further, exercise intensity above 70% $\dot{V}O_{2max}$ could be painful or unpleasant [20]. Collectively the above findings along with the experimental condition of mean % $\dot{V}O_{2max}$ over 70% $\dot{V}O_{2max}$ in our study (Table 1), it can be suggested that the participants attention in the control condition might be associative. Therefore, RPEover and RPEperi were expected to be lower in the AD and ID conditions than in the control condition.

The use of distractions during high intensity exercises may alter the respiratory response. Schücker et al. [36] reported that respiratory rate during 30-min treadmill running at 85% $\dot{V}O_{2max}$ was significantly lower when focusing on breathing (internal focus) than when focusing on video (external focus), whereas $\dot{V}_E$ did not differ among internal focus, external focus, and control. Schücker et al. [37] and Schücker and Parrington [38] reported that the RR was lower when focusing on breathing (internal focus) than when focusing on the surroundings [37] and video, [38] whereas $\dot{V}_E$ did not differ in both conditions. Our finding that the RR was higher in both distractions is consistent with previous findings considering that participants attention is more internal in the control condition. Therefore, the participant's attention in control condition in our study might be internal focus. And, previous studies have reported that the respiratory volume was higher with internal focus than with external focus and control [36-38]. Assuming that in our study, participants' attention may be more internal in the control condition, the increase in $\dot{V}_E$ in both distraction conditions could have been caused by changes in respiratory volume and RR due to the use of distraction.

In our study, RPEover and RPEperi did not change, despite the RR and ventilation rate changed in both distraction conditions. A previous study examined factors influencing RPE during 30-min of cycling exercise at 48, 60, and 68% $\dot{V}O_{2max}$ and indicated that $\dot{V}_E$ contributed significantly to RPE at 5- and 15-min, whereas RR contributed significantly to RPE at 30-min [34]. Another study by Nicolo et al. [39] examined the relationship between respiratory data and perceived exertion using time to exhaustion cycling test at 75 and 90% peak power output and suggested that RR was a good marker of perceived effort as measured by Borg's RPE 6-20 scale. Given these reports, it is expected that the changes in RR and ventilation during exercise may lead to change perceived exertion during exercise.

One possible reason for the non-significant main effect of condition on RPE is that the method used for active distraction may be inadequate or insufficient to reduce RPE. Based on the parallel processing model [15], the greater the distraction from bodily sensations, the lesser the perceived exertion might be. In our study, participants in the active distraction group heard four songs and counted specific words. Chow and Etnier [40] reported that RPE during 20-min cycling at 125% ventilatory threshold (VT) in music and video combined condition was lower than that in music only and video only condition. And, RPE during running at ±10% VT in music and video condition was lowest compared to music condition and control condition [41]. Given that these studies used both auditory and visual stimuli, the participants' attention might have been more distracted from their bodily sensations compared to using only music or video as a distraction. In our study, participants in the active distraction condition listened only to music. Therefore, the method used for active distraction in our study might have been insufficient for distracting bodily sensations. And, none of the participants answered the correct number of times that specific words heard. It was suggested that the participants in AD condition could not pay attention to songs adequately. Presumably, it was difficult for the participants to focus on counting the specific words during high intensity exercise.

Similar to RPE, our study suggests that active and involuntary distraction did not influence affective responses. Although there was a significant main effect of condition for N-affect, the values of change before and after the experimental trial in the AD and ID conditions were 2.34. We concluded that the effect of distraction on N-affect might be equivalent because the values of change before and after the experimental trial in the AD and ID conditions were the same. A previous study suggested that distraction during

10-min cycling at RPE 13 was preferable for exercising with a sense of comfort [42]. A study by Arai et al. [43] suggested that the influence of distraction favored post-walking emotions when participants walked below the RPE 13 level. In our study, the RPEover was > 13 at the end of the exercise (Table 5). Collectively these results along with the results of our study suggest that the effect of distraction on affective responses associated with exercise might be smaller for an exercise intensity above RPE 13. Therefore, higher perceived exertion could lead to a disappearance of the effect of distractions on affective responses. Tranquility increased more during the recovery period than immediately after self-paced exercise [24]. In this study, tranquility was measured immediately after the task. Therefore, the measurement timing could have also influenced the tranquility results. Future studies should examine the influence of the measurement timing on tranquility and distraction.

Our study has some limitations. First, it is unclear whether the same results would be obtained in women because the participants were healthy young male adults. Similar to our study, previous studies examining the effect of attentional focus on RPE using constant load cycling exercise reported that RPE was lower in external focus than in internal focus when the participants cycled at 60% $\dot{V}O_{2max}$ [9] and 75% $\dot{V}O_{2max}$ [10]. Additionally, Aghdaei et al. [44] reported that RPE in dissociative-external focus was lower than that in associative attentional focus when the participants ran at 70 % maximum velocity. The participants in these three studies were all females. Considering the results of these studies and those of our study, the effect of distraction on the RPE may be more pronounced in women. On the other hand, Hatfields et al. [45] examined the effects of external focus on RPE during 12-min running at below VT in men. However, no other study has examined the effect of attentional focus on the RPE during constant-load exercise in men. Therefore, future studies should examine the influence of gender on the effects of distraction on RPE.

Second, other methods may be effective in treating active distractions. In our study, we asked participants to count specific words in the music played in the AD condition. Based on the parallel processing model [15], counting the specific words would dissociate participants attention than in the ID condition because participants attention might be greatly distracted from bodily sensations. If participants attention is greatly distracted by bodily sensations, perceived exertion would decrease. However, the RPEs values for the two distractions in the present study did not differ. Therefore, the distraction levels of bodily sensations in the AD and ID conditions may be equivalent. Previous studies have used various methods such as counting specific words [11], paying attention to the environment [10], and watching a video [36] corresponding to active distraction. The RPE in AD and ID conditions might be lower than that in controls using the methods-such as paying attention to the environment and watching a video. However, the appropriate methods for active distraction are unclear. Future studies should examine what methods are most appropriate for distracting the participant's attention from their bodily sensations.

Third, the measurement of RPE and respiratory parameters during the main task may have influenced the RPE results. Corbett et al. [46)] reported that measurement frequency influences RPE during submaximal treadmill running. Therefore, the measurement frequency in our study could have influenced the RPEover and RPEperi results. Moreover, wearing masks to collect respiratory data during cycling was expected to increase breathing focus, and can decrease the attention level of distraction. Future studies should examine the effect of distraction on RPE and affective responses in situations in which factors that cause discomfort and inhibit attentional distraction from bodily sensations.

In conclusion, our results suggested that active and involuntary distractions did not influence perceived exertion during 20-min cycling at 70% $\dot{V}O_{2max}$. Furthermore, distraction may not enhance positive affective responses. One possible reason for these results is that the method used as distractions may be inadequate to change perceived exertion and affective responses. On the other hand, both distractions may influence respiratory responses during 20-min cycling at 70% $\dot{V}O_{2max}$. Further studies are required to examine how the effects of distraction on perceived exertion and affective responses change according to gender and distraction methods. In addition, further studies are required to examine appropriate methods that promote distraction from bodily sensations during high-intensity exercise.

Contributions: Experiment conception and design: S.W., Y.H. Experiment implementation: S. W. Data analysis: S. W. Paper composition: S. W. Analyzing and writing advisory: Y.H. All authors approved the final version of the manuscript.

Conflicts of Interest: The authors declare that there are no conflicts of interest.

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Table 1. % $\dot{V}_{O2max}$ during 20-min main cycling in each condition.

	Time									
	1min	2min	3min	4min	5min	6min	7min	8min	9min	10min
C	49.16 ± 4.79	66.50 ± 4.23	70.37 ± 4.60	71.17 ± 5.46	71.39 ± 6.31	73.50 ± 6.67	73.48 ± 7.02	73.85 ± 6.90	74.11 ± 7.66	73.74 ± 7.19
AD	50.95 ± 4.46	66.75 ± 4.29	69.46 ± 4.97	71.28 ± 5.26	71.58 ± 5.79	73.89 ± 5.81	73.59 ± 6.06	73.55 ± 6.61	73.98 ± 6.61	74.09 ± 7.21
ID	49.74 ± 3.67	66.30 ± 3.13	69.15 ± 4.06	70.64 ± 4.57	71.17 ± 5.29	72.16 ± 5.09	72.41 ± 5.70	72.55 ± 5.89	73.54 ± 6.36	73.18 ± 7.00
Total	49.95 ± 4.32	66.51 ± 3.85	69.66 ± 4.50	71.03 ± 5.02	71.38 ± 5.70	73.18 ± 5.83	73.16 ± 6.19	73.32 ± 6.38	73.88 ± 6.77	73.88 ± 7.01

	Time									
	11min	12min	13min	14min	15min	16min	17min	18min	19min	20min
C	74.31 ± 7.33	74.20 ± 7.03	74.41 ± 7.10	75.05 ± 7.34	74.04 ± 6.90	74.89 ± 6.78	74.12 ± 6.73	75.12 ± 6.63	74.93 ± 6.67	74.80 ± 6.84
AD	75.61 ±6.88	75.15 ± 6.64	75.21 ± 7.00	75.54 ± 6.93	75.18 ± 7.25	76.40 ± 7.36	76.09 ± 7.65	75.93 ± 7.58	76.06 ± 7.60	75.86 ± 8.30
ID	73.70 ± 6.45	73.91 ± 7.09	74.37 ± 6.43	74.02 ± 6.57	74.14 ± 6.57	74.42 ± 6.47	74.71 ± 7.47	74.50 ± 7.30	75.13 ± 7.45	75.23 ± 7.43
Total	74.54 ± 6.81	74.42 ± 6.81	74.66 ± 6.73	74.87 ± 6.85	74.45 ± 6.80	75.23 ± 6.80	74.97 ± 7.20	75.19 ± 7.06	75.37 ± 7.13	75.30 ± 7.41

Note. This table represents the % $\dot{V}_{O2max}$ during 20-min main cycling in each condition. Mean value and standard deviation were described. C = control condition, AD = active distraction condition; ID = involuntary distraction condition. No significant main effect of condition and interaction. Oxygen consumption increased over time in all conditions.

Table 2. % HR_{max} during 20-min main cycling in each condition.

	Time									
	1min	2min	3min	4min	5min	6min	7min	8min	9min	10min
C	59.60 ± 5.76	69.20 ± 6.28	72.07 ± 6.11	73.31 ± 6.34	74.76 ± 6.47	76.05 ± 6.40	77.33 ± 6.54	78.22 ± 6.67	79.26 ± 6.69	79.61 ± 6.73
AD	61.78 ± 4.51	69.40 ± 4.99	71.86 ± 4.95	74.20 ± 4.85	75.19 ± 5.18	76.75 ± 4.96	78.47 ± 5.22	79.28 ± 5.22	79.97 ± 5.41	80.01 ± 5.53
ID	61.07 ± 3.99	69.51 ± 4.71	72.44 ± 5.04	73.81 ± 5.63	75.27 ± 5.89	76.56 ± 5.92	78.11 ± 6.38	78.90 ± 6.53	79.79 ± 6.84	80.33 ± 7.04
Total	60.82 ± 4.81	69.37 ± 5.27	72.12 ± 5.29	73.77 ± 5.55	75.07 ± 5.76	76.45 ± 5.69	77.97 ± 5.98	78.80 ± 6.07	79.68 ± 6.23	79.98 ± 6.35

	Time									
	11min	12min	13min	14min	15min	16min	17min	18min	19min	20min
C	80.33 ± 6.65	80.85 ± 6.89	81.28 ± 6.55	81.86 ± 6.62	82.21 ± 6.54	82.39 ± 6.48	82.84 ± 6.33	83.54 ± 6.31	83.82 ± 6.37	83.97 ± 6.41
AD	81.17 ± 5.44	81.63 ± 6.05	82.15 ± 5.79	82.76 ± 5.69	83.06 ± 5.90	83.03 ± 5.69	83.89 ± 5.90	84.22 ± 5.66	84.51 ± 5.38	84.56 ± 5.55
ID	80.85 ± 6.93	81.54 ± 7.22	82.03 ± 7.21	82.31 ± 7.32	82.58 ± 7.33	82.87 ± 7.36	83.30 ± 7.05	83.68 ± 7.56	84.14 ± 7.31	84.17 ± 7.58
Total	80.78 ± 6.26	81.34 ± 6.62	81.82 ± 6.43	82.31 ± 6.46	82.62 ± 6.50	82.76 ± 6.43	83.35 ± 6.34	83.81 ± 6.44	84.16 ± 6.29	84.23 ± 6.45

Note. This table represents the % HR_{max} during 20-min main cycling in each condition. Mean value and standard deviation were described. C = control condition, AD = active distraction condition; ID = involuntary distraction condition. No significant main effect of condition and interaction. HR increased over time in all conditions.

Table 3. $\dot{V}_E$ during 20-min main cycling in each condition.

	Time									
	1min	2min	3min	4min	5min	6min	7min	8min	9min	10min
C	59.60 ± 5.76	69.20 ± 6.28	72.07 ± 6.11	73.31 ± 6.34	74.76 ± 6.47	76.05 ± 6.40	77.33 ± 6.54	78.22 ± 6.67	79.26 ± 6.69	79.61 ± 6.73
AD	61.78 ± 4.51	69.40 ± 4.99	71.86 ± 4.95	74.20 ± 4.85	75.19 ± 5.18	76.75 ± 4.96	78.47 ± 5.22	79.28 ± 5.22	79.97 ± 5.41	80.01 ± 5.53
ID	61.07 ± 3.99	69.51 ± 4.71	72.44 ± 5.04	73.81 ± 5.63	75.27 ± 5.89	76.56 ± 5.92	78.11 ± 6.38	78.90 ± 6.53	79.79 ± 6.84	80.33 ± 7.04
Total	60.82 ± 4.81	69.37 ± 5.27	72.12 ± 5.29	73.77 ± 5.55	75.07 ± 5.76	76.45 ± 5.69	77.97 ± 5.98	78.80 ± 6.07	79.68 ± 6.23	79.98 ± 6.35

	Time									
	11min	12min	13min	14min	15min	16min	17min	18min	19min	20min
C	80.33 ± 6.65	80.85 ± 6.89	81.28 ± 6.55	81.86 ± 6.62	82.21 ± 6.54	82.39 ± 6.48	82.84 ± 6.33	83.54 ± 6.31	83.82 ± 6.37	83.97 ± 6.41
AD	81.17 ± 5.44	81.63 ± 6.05	82.15 ± 5.79	82.76 ± 5.69	83.06 ± 5.90	83.03 ± 5.69	83.89 ± 5.90	84.22 ± 5.66	84.51 ± 5.38	84.56 ± 5.55
ID	80.85 ± 6.93	81.54 ± 7.22	82.03 ± 7.21	82.31 ± 7.32	82.58 ± 7.33	82.87 ± 7.36	83.30 ± 7.05	83.68 ± 7.56	84.14 ± 7.31	84.17 ± 7.58
Total	80.78 ± 6.26	81.34 ± 6.62	81.82 ± 6.43	82.31 ± 6.46	82.62 ± 6.50	82.76 ± 6.43	83.35 ± 6.34	83.81 ± 6.44	84.16 ± 6.29	84.23 ± 6.45

Note. This table represents the minute ventilation ($\dot{V}_E$) during 20-min main cycling in each condition. Mean value and standard deviation were described. C = control condition, AD = active distraction condition; ID = involuntary distraction condition. Significant main effects of condition and time were observed. $\dot{V}_E$ in control condition was lower than that in AD and ID condition. And $\dot{V}_E$ increased over time in all conditions.

Table 4. RR during 20-min main cycling in each condition.

	Time									
	1min	2min	3min	4min	5min	6min	7min	8min	9min	10min
C	24.07 ± 4.63	26.74 ± 5.40	28.75 ± 4.76	29.70 ± 5.32	30.55 ± 4.53	31.04 ± 4.53	31.55 ± 4.72	31.92 ± 5.00	32.09 ± 4.66	32.40 ± 4.55
AD	25.76 ± 3.06	29.11 ± 3.73	31.11 ± 3.52	32.17 ± 3.65	32.79 ± 3.65	33.55 ± 3.93	34.59 ± 4.25	35.39 ± 4.59	36.20 ± 5.27	35.41 ± 5.91
ID	25.31 ± 4.37	28.08 ± 4.21	29.89 ± 4.73	31.15 ± 4.79	31.86 ± 4.41	32.83 ± 5.25	33.43 ± 5.30	33.83 ± 5.74	34.76 ± 5.26	34.89 ± 5.43
Total	25.05 ± 4.06	27.98 ± 4.52	29.91 ± 4.40	31.01 ± 4.67	31.73 ± 4.24	32.47 ± 4.64	33.19 ± 4.85	33.71 ± 5.23	34.35 ± 5.26	34.23 ± 5.39

	Time									
	11min	12min	13min	14min	15min	16min	17min	18min	19min	20min
C	33.12 ± 5.42	33.70 ± 5.06	33.99 ± 5.85	35.20 ± 6.35	35.92 ± 6.55	35.90 ± 7.51	36.34 ± 7.77	36.35 ± 7.69	36.69 ± 7.61	37.31 ±7.64
AD	36.98 ± 5.56	38.16 ± 6.14	38.37 ± 5.58	38.64 ± 6.14	38.08 ± 6.77	39.04 ± 7.00	39.79 ± 6.87	40.24 ± 6.48	40.88 ± 6.23	40.94 ± 6.53
ID	35.13 ± 5.38	35.19 ± 5.32	35.58 ± 5.69	36.58 ± 6.12	36.38 ± 6.54	37.26 ± 6.78	37.05 ± 6.67	37.25 ± 7.69	37.84 ± 7.87	39.20 ± 8.68
Total	35.08 ± 5.58	35.68 ± 5.74	35.98 ± 5.89	36.81 ± 6.25	36.79 ± 6.56	37.40 ± 7.09	37.73 ± 7.14	37.95 ± 7.36	38.47 ± 7.35	39.15 ± 7.67

Note. This table represents the respiratory rate (RR) during 20-min main cycling in each condition. Mean value and standard deviation were described. C = control condition, AD = active distraction condition; ID = involuntary distraction condition. Significant main effects of condition and time were observed. RR in control condition was lower than that in AD and ID condition. And RR increased over time in all conditions.

Table 5. Mean RPE in each condition and statistical analysis.

	Condition			ANOVA		
	Control	Active Distraction	Involuntary Distraction	Effect	*F* ratio	*P* value
RPE overall						
5min	12.67 (1.33)	12.72 (1.60)	13.11 (1.08)	C	0.23	0.79
10min	13.61 (1.38)	13.78 (1.59)	13.67 (1.14)			
15min	14.39 (1.46)	14.50 (1.72)	14.39 (1.46)	T	32.39	< 0.01
20min	14.67 (1.14)	14.78 (1.83)	14.56 (1.42)			
Total	13.83 (1.52)	13.94 (1.84)	13.93 (1.39)	C×T	0.36	0.91
RPE peripheral						
5min	13.67 (1.14)	13.67 (1.81)	14.28 (1.41)	C	0.93	0.40
10min	14.56 (1.82)	15.00 (1.61)	15.00 (1.41)			
15min	15.22 (1.90)	15.56 (2.01)	15.22 (1.48)	T	29.22	< 0.01
20min	15.83 (1.58)	15.94 (2.10)	15.67 (1.81)			
Total	14.82 (1.79)	15.04 (2.04)	15.04 (1.59)	C×T	0.85	0.53

Note. Standard deviations are presented in parentheses. In the ANOVA columns, C represents the condition effect, T represents the measurement time effect, and C ×T represents the condition and measurement time interaction.

Table 6. Descriptive statistics for affective responses and the results of statistical analysis.

	Time		ANOVA		
	Pre	Post	Effect	*F* ratio	*P* value
Positive engagement					
Control	9.67 (3.09)	12.72 (3.30)	C	0.52	0.60
Active Distraction	9.00 (2.43)	12.28 (3.37)	T	38.53	< 0.01
Involuntary Distraction	9.11 (2.03)	12.22 (2.92)	C ×T	0.07	0.93
Negative affect					
Control	7.28 (2.99)	5.50 (1.92)	C	4.19	0.02
Active Distraction	8.28 (2.78)	5.94 (1.70)	T	26.15	< 0.01
Involuntary Distraction	7.06 (3.11)	4.72 (0.89)	C ×T	0.30	0.74
Tranquility					
Control	12.78 (2.88)	13.11 (3.80)	C	0.80	0.45
Active Distraction	13.11 (2.03)	13.89 (3.68)	T	1.66	0.20
Involuntary Distraction	13.06 (2.71)	14.11 (3.43)	C ×T	0.09	0.91

Note. Means and standard deviations were shown. Standard deviations are presented in parentheses. In ANOVA columns, C represents condition effect, T represents measurement time effect, C ×T represents condition and time interaction.