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Original Article

Differentiated ratings of perceived exertion between overweight and non-overweight children during submaximal cycling

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ABSTRACT

Objective: Few studies have examined differences in ratings of perceived exertion (RPE) between overweight (OW) and non-OW (NW) youth. With lower voluntary participation in physical activity in OW children, it seems plausible that these youth may experience elevated RPE. Therefore, this study compared RPE during two separate steady-state cycling bouts OW (>95th body mass index [BMI] percentile) and NW (<90th BMI percentile) children.

Methods: Participants completed one of two 20-min cycling trials; one performed at 70% age-predicted peak heart rate (HR) (70%) (OW n = 12 and NW n = 21) and a self-selected intensity (SS) (OW n = 6 and NW n = 13) with RPE overall, RPE legs (RPE-L), and RPE chest estimated at 5, 10, 15, and 20 min.

Results: A repeated measures ANOVA revealed that OW individuals had significantly lower RPE-L values at 5, 15, and 20 min during the SS trial. No significant differences were identified during the 70% trial.

Conclusions: OW youth do not perceive cycling at 70% age-predicted peak HR or at SS intensities more difficult than NW children. It may be that cycling could serve as an attractive mode to encourage physical activity in this population and perhaps increase self-efficacy of exercise in this population.

Keywords: Body mass index, children, perception of effort, physical activity

Introduction

The increasing trend in overweight (OW) and obesity in children is staggering. Results from a meta-analysis reported that 6–11 year old age group to have the largest trend in the prevalence in becoming OW from a rate of ~4% in the 1970's progressing toward ~18% in 2004.[1] A more recent report estimates ~32% of children and adolescents are either OW or obese.[2] Problems associated with obesity are not only limited to physiological issues (e.g., diabetes and hypercholesterolemia). Whetstone *et al*.[3] showed a significant association between perceived weight status and suicidal thoughts and actions in middle school youth. Future magnifications to health-care services and costs consequent to increasing rates of obesity are difficult to estimate but should also be included when determining the negative implications of obesity. Further, as OW children most often become OW adults,[4,5] the absence of effective treatment or prevention seems the problem only stands to worsen.

OW and obesity often involve imbalanced energy intake and expenditure with unhealthy weight status frequently associated with inadequate physical activity. Lohman *et al*.[6] and Sulemana *et al*.[7] found negative relationships between physical activity and weight status. Deforche *et al*.[8] found lower sport participation as well as a less positive attitude toward physical activity in OW and obese (vs. normal weight) adolescents. OW children may believe that their activity level is similar to normal weight children even though their activity level is voluntarily reduced earlier in life than children who are not classified as OW.[9] Reasons for this voluntary reduction are currently unclear. Using questionnaires, it was determined that 9–11-year-old OW females were significantly more likely than non-OW (NW) females to report barriers to completing weight-bearing physical activity although details regarding perceived barriers are not well understood.[10] Much like other chronic diseases, prevention of obesity is preferable to treatment but difficulty exists in achieving adherence to routine physical activity among OW and obese individuals.[11] Identifying potential barriers to inadequate physical activity may offer insight on removing barriers and increasing participation and self-efficacy among OW and obese youth.

Ratings of perceived exertion (RPE) offer a convenient model for subjectively evaluating exertion associated with physical

activity and have also been noted as correlates of self-efficacy. One application for RPE is an acute estimation of exercise intensity in which an exerciser provides a rating corresponding to how difficult a given exercise load feels. RPEs are also used in an estimation–production paradigm. In this approach, an individual is prescribed a designated RPE (numerical value) with the expectation they will self-adjust their workload to achieve the target RPE. Perceived exertion has been validated in youth participants including the estimation as well as the estimation–production paradigm.[12] However, few studies have examined potential differences for RPE between OW/obese and NW youth. Considering their consistently lower voluntary participation in physical activity, it is plausible that, compared to NW children, OW or obese youth may experience elevated feelings of exertion during exercise and consequently participate less frequently. This, however, is not well understood. Therefore, the aim of this study was to compare the overall as well as differentiated feelings of exertion of OW and NW elementary-age students during two different bouts of submaximal cycling.

Methods

Experimental design

To fully investigate the influence of exercise intensity on perceived exertion in OW and NW youth, two different exercise protocols were utilized. There were two different sets of participants that completed a 20-min submaximal cycling bout at either (a) 70% of their predicted peak HR (220-age) where investigators controlled the resistance to maintain a constant HR at the exercise performed or (b) at a self-selected (SS) intensity in which the children manipulated the resistance to tolerable levels throughout the 20-min bout. That is, participants exercised at an intensity they preferred for a 20-min bout. The subsequent methods and results below will be shown separately, corresponding to respective trials.

Participants

A total of 52 4th and 5th Grade students from a local elementary school volunteered for the study. In accordance with the institutional review board, all participants were provided assent to participate the following written informed consent provided by their parent/guardian before data collection. The testing was conducted during the children's regularly scheduled physical education class; therefore, time of testing for all individuals performing the experiment was consistent. Exercise sessions were performed in a secluded room on school premises to maintain familiarity. Testing sessions were completely voluntary and all individuals whose parent/guardian provided consent were afforded the opportunity to participate.

Procedure

Before performing any exercise, all volunteers were measured for anthropometric data. Body weight and height were assessed using a calibrated beam scale (Detecto, Webb City, MO). Body mass index (BMI) (kg·m^{-2}) was determined and used to stratify the participants into subgroups of OW and NW. Individuals with a BMI ≥21 (95th–99th percentile) were considered OW (OW; n = 18), while those individuals with a BMI ≤19 were considered NW (NW; n = 34). Following descriptive information, participants completed one of two experimental protocols that consisted of 20-min of submaximal cycling at either (a) a SS intensity or (b) at an intensity to elicit 70% of the individual's predicted peak HR (220-age).

SS Intensity

From the total sample (n = 52), 19 children (13 girls and 9 boys) participated in this trial. All individuals performing this trial completed a 20-min exercise session on calibrated cycle ergometer that was specially adapted for pediatric use (CatEye Ergociser EC-1600, Cat Eye Co., LLC, Osaka, Japan). Participants were allowed to adjust their seat for maximal comfort before starting the test and were fitted with a heart rate (HR) belt (Polar Inc. Stamford, CT) to monitor HR throughout the bout. Each child was shown a picture of the children's cycle-specific OMNI scale of perceived exertion[12] before exercising and was given detailed instructions on its use and specific instructions of how to distinguish overall RPE (RPE-O), RPE of their legs (RPE-L) as well as RPE of their chest (i.e., breathing) (RPE-C). All participants were given the opportunity to ask any questions regarding the testing procedures before starting.

Participants were asked to select a comfortable intensity they would choose if they were going to ride the bike for 20 min. Workload was selected while pedaling the ergometer at 60 rev/min. Participants were allowed to manipulate the resistance throughout the 20-min bout if it became too difficult to continue or if they wished to increase the workload.

Seventy percentage age-predicted peak HR

From the total sample (n = 52), 33 children (21 girls and 12 boys) were participated in this session. This trial was conducted identical to the SS trial; however, participants were blinded to the resistance and HR. Investigators regularly (as needed) adjusted the resistance settings to maintain each individual within ±2 beats/min of the target HR (i.e., 70% HR_{peak}).

Data analysis

All data were analyzed utilizing the Statistical Package for the Social Sciences (v. 22.0, IBM, Armonk, NY.). Descriptive data were subjected to independent t-tests to confirm differences in body weight and BMI between OW and NW groups. A 2 (group) × 4 (time) repeated measures ANOVA was used to determine differences between groups with univariate post hoc procedures performed where appropriate. Between-group univariate *post hoc* analyses were used to identify where significant differences occurred and effect sizes were calculated

using Cohen's *d*. In accordance with Cohen,[13] effect sizes of 0.20, 0.50, and 0.80 between groups were considered small, moderate, and large, respectively. All data are reported as mean ± standard deviation. Statistical significance was determined *a priori* at the 0.05 level.

Results

Descriptive characteristics for all participants in the SS and 70% trials are provided in Table 1.

The physiologic and perceptual values recorded throughout the SS and 70% trials are shown in Figures 1a–4c, respectively. More specifically, Figure 1a and b models the HR response between groups across both the trials. Figures 2a and b and 3a–c are the differentiated RPE responses between groups for the SS and 70% heart maximum trials, respectively. Finally, Figure 4a and b models the power output achieved between groups during both the trials.

SS intensity trial

Figures 2a–4b models the results from the trials. There was a significant main effect for RPE-L ($P < 0.05$) between groups with *post-hoc* measures showing OW children having significantly lower RPE-L values at 5 min ($P < 0.01$; $d = 1.84$), 15 min ($P = 0.02$; $d = 1.30$), and 20 min ($P = 0.02$; $d = 1.24$) and approached significance at 10 min ($P = 0.06$; $d = 1.00$). In addition, all differences were considered large with respect to the calculated effect size, suggesting that the differences were meaningful. In addition, RPE-O between the two groups, while not statistically significant, did tend to be lower in OW versus NW and approached significance ($P = 0.15$). However, there was no significant main effect between groups RPE-C ($P = 0.53$) values between the two groups. There were also no significant differences in HR between OW and NW children throughout the 20-min bout of exercise ($P = 0.41$). In addition, no significant main effect was observed between overweight and non-overweight children with regard to power production ($P = 0.77$) maintained throughout the trial.

70% age-predicted peak HR trial

There was no significant main effect for recorded HR values between OW and NW children during the 70% trial ($P = 0.20$). In addition, no significant main effect was identified for RPE-O ($P = 0.97$), RPE-L ($P = 0.69$), or RPE-C ($P = 0.71$) between groups. There was no significant difference found regarding power outputs ($P = 0.32$) between OW and NW children during this trial.

Discussion

This study compared RPE responses of OW and NW children during two different submaximal cycling sessions. The novel findings from this study indicate that, during SS cycling, OW children estimate lower levels of effort while during clamped exercise at 70% of HR_{peak} report similar levels of differentiated exertion when compared to NW children. There has been evidence to show that levels of physical activity are associated with enjoyment and/or effort of the activity in children.[14] In turn, the lack of physical activity may be a precipitating factor in the onset of obesity that carries over with the youth into adulthood.[5] Results from the current study suggest that, during submaximal cycling, OW children will demonstrate similar and in some cases lower perceived exertion despite higher work rates than NW children. While there exist volumes of data regarding contributing factors to childhood obesity, there exist very limited research addressing the effect of submaximal exercise performed at a SS versus a clamped level of intensity, in this case, 70% of estimated HR_{peak}.[15] This is surprising as the use of RPE is popular in adolescents and adults performing physical activity and exercise. An attractive component and one that should seem attractive to those working with children are the RPE as a gestalt. That is, RPE is mediated by a number of different factors, both intrinsic and extrinsic, to provide psychobiological ratings of whole-body strain. Moreover, as seen in this study, the inclusion of differentiated RPE estimations (i.e.,specific to different body areas) is, especially, attractive as they isolate more specifically the locations of the body where discomfort is greatest. Further, in the case of children, differentiated estimations could provide information relative to the types of exercise they enjoy.[16-19]

Data from this study reveal that OW children report significantly lower RPE-L values than NW children do during submaximal cycling at SS intensities [Figure 2b]. Interestingly, these differences seem to occur without any significant difference in the 70% HR_{peak} trial and no differences in power output [Figure 4a and b] between trials. This may

Table 1: Descriptive characteristics of all individuals in the SS intensity trial (n=19) and 70% peak HR trial (n=33). All values are mean±SD

Trial	Age (year)	Height (m)	Weight (kg)	BMI (kg.m^{-2})
Self selected				
OW (n=6)	10.2±0.4	1.42±0.01	47.0±11.0	23.1±2.2
NW (n=13)	9.4±0.5	1.38±0.06	31.7±4.1*	16.3±1.7*
70% peak HR				
OW (n=12)	10.5±0.7	1.46±0.08	50.3±8.3	23.5±1.9
NW (n=21)	10.3±0.6	1.43±0.08	33.1±6.8*	16.0±2.0*

*P<0.05 between groups within a given trial, OW: Overweight, NW: Non-overweight, HR: Heart rate, SD: Standard deviation, SS: Self-selected, BMI: Body mass index

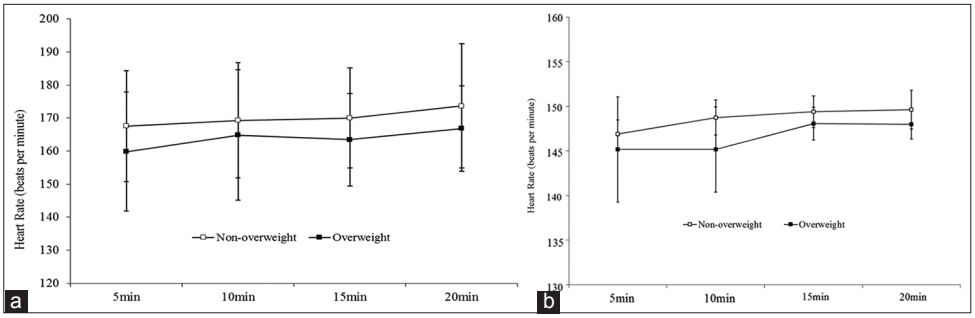

Figure 1: Heart rate (HR) response of overweight and non-overweight children performing 20-min of submaximal cycling at (a) a self-selected intensity or (b) at 70% predicted HR_{peak}

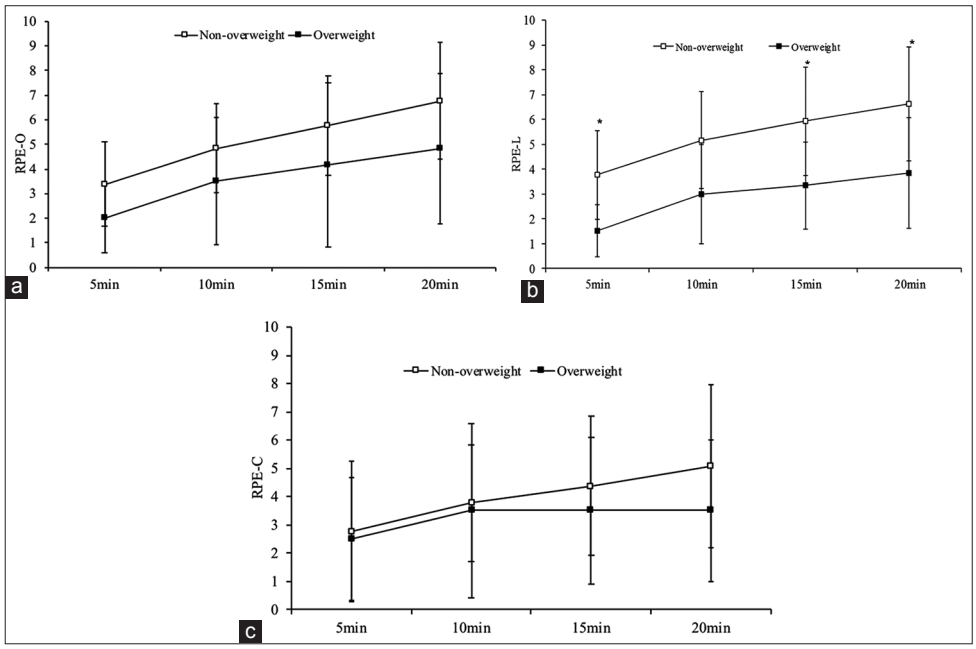

Figure 2: Differentiated feelings of exertion (a) overall, (b) legs, and (c) chest achieved by overweight and non-overweight children during 20-min of cycling at a self-selected intensity. There was a main effect for ratings of perceived exertion legs ($P = 0.02$) between groups. *Significantly different at $P < 0.05$

suggest that, given the opportunity to self-pace, OW children will produce slightly higher power output (i.e., greater work performed) but perceive significantly lower feelings of exertion relative to the lower body. While no studies exist comparing OW and NW children and differentiated RPE, these findings are still somewhat surprising. Marinov *et al*.[15] found that obese children would report significantly higher RPE values (compared to normal weight children) due to a greater awareness of fatigue. However, in that study, children were asked to perform incremental exercise on a treadmill and, thus, incurred a higher metabolic strain likely mediating the changes in RPE. Indeed, there are data identifying a moderate-to-strong relationship between metabolic and cardiovascular strains with RPE in children.[20,21] Perhaps, a reason that the OW children in this study produced significantly lower RPE-L is due to cycling not being a skill-based activity and, perhaps more importantly, non-weight bearing. It has been suggested that obese children display reduced psychomotor capability and, because of that, will tend to produce higher perceptions of effort when compared to normal weight individuals.[20] This may be additional evidence supporting the notion that cycling may be a valuable mode of physical activity in overweight and/or obese children. That is, if the activity is perceived as less taxing (vs. weight-bearing modes), self-efficacy, enjoyment, and consequently compliance may be enhanced in this population.[18] Future research is warranted to directly investigate this possibility.

Efficacy of exercise is known to be an integral mediator of RPE during a bout of activity across all ages.[22] Moreover, there is an established link between efficacy and RPE on participation in physical activity.[23] The findings from this study suggest, then, that a plausible intervention method to encourage physical activity or exercise in OW youth would be submaximal cycling at SS intensities. To that end, it seems plausible that, at the conclusion of the 20-min SS session,

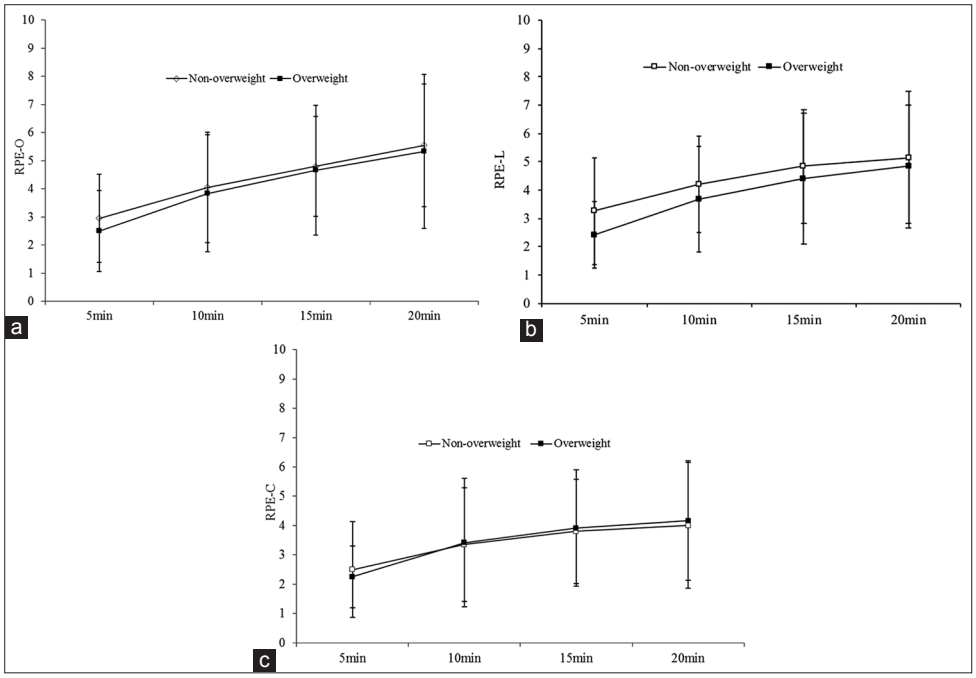

Figure 3: Differentiated feelings of exertion (a) overall (b) legs and (c) chest achieved by overweight and non-overweight children during 20-min of cycling at 70% predicted heart rate$_{peak}$

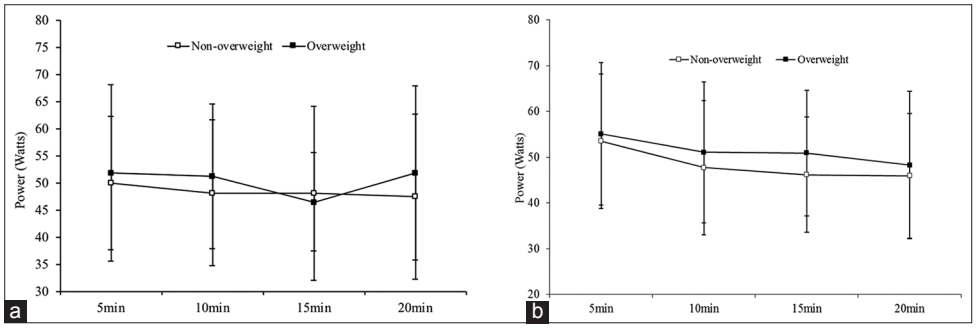

Figure 4: Power outputs of overweight and non-overweight children during 20-min of submaximal cycling at (a) a self-selected intensity and (b) 70% predicted heart rate$_{peak}$

the OW individuals may have experienced increased self-efficacy, and in the future, strategies to reinforce those feelings may begin to create positive feelings toward exercise and physical activity. Future investigations regarding the impact of submaximal cycling on OW children and the consequent feelings of self-efficacy and exercise adherence should shed further light on this relationship.

Data from this study also seem to show that allowing children (OW and NW) to self-regulate (vs. prescribing a workload) results in achieving greater cardiovascular strain. As seen in Figure 1-4, children tend to self-select higher power outputs than when clamped at 70% of HR$_{peak}$ resulting in higher HR than what was targeted while concurrently reporting similar levels of perceptual strain. This is consistent between OW and NW children in this study. A growing body of literature suggests that RPE is adjusted in a feed-forward manner (vs. feedback) when an individual is aware of either the time or distance of exercise remaining.[24,25] It seems that the children in this study were able to self-regulate their intensities quite competently in a paradigm where they were simply aware of how long they were to perform the exercise. When given the freedom to choose their power output, both OW and NW children tend to produce higher intensities than when performing "clamped" exercise at a moderate intensity but produce similar RPE values. Ultimately, this may suggest that, within reason, children will produce optimal intensities to meet recommendations for improving or maintaining cardiovascular health. This, while experiencing similar levels of exertion (i.e., discomfort) during the session and quite possibly leading to higher levels of efficacy post-exercise. To the best of our knowledge, this is the first study to examine the influence of "clamped" vs. SS physical activity in youth and the notion of children performing self-regulated exercise to meet

exercise standards. Certainly, more studies are needed to full explore this notion, and future works should aim to include the measures of self-efficacy to further understand the merits of the relationship it has with perceived exertion.

Conclusions

Findings from this study show that, during SS bouts of cycling, OW children will experience lower localized discomfort in the legs (reflected in RPE-L) compared to NW children with no differences in responses when clamped at 70% HR_{peak}. This may suggest that, for OW children, cycling (vs. other weight-bearing activity) may be an optimal and effective modality to increase physical activity and exercise participation. Findings also suggest that children, independent of weight classification, are able to effectively self-regulate exercise performance during 20 min of cycling. Therefore, this study would suggest that it is indeed worthy of merit to encourage young children who are overweight to begin exercising using a SS intensity on a stationary bike. Subsequently, this could allow this population to achieve both optimal intensities to improve health/cardiovascular fitness while concomitantly minimizing some discomfort associated with exercise to promote increased voluntary physical activity in the future. No financial or material support of any kind was received for the work described in this article.

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