Efficacy of perceptual *versus* heart rate monitoring in the development of endurance

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The purpose of this investigation was to compare the effectiveness of using ratings of perceived exertion (RPE) with heart rate in the monitoring of exercise intensity during aerobic dance instruction. Thirty-eight students who enrolled in aerobic dance classes used heart rate to monitor exercise intensity while 38 additional students used RPE to monitor exercise intensity during a 14-week course. Classes met twice a week for 50 min and all outside workouts were recorded. The groups did not differ with respect to the number of outside workouts. The dependent variable was endurance performance as measured by the distance run in 15 min. Data were analysed with a repeated measures analysis of variance (ANOVA) for multifactor experiments. There were significant trials ($P < 0.0001$) and interaction ($P < 0.05$) effects, and both groups improved significantly in endurance performance during 14 weeks of training. However, the group using RPE to monitor exercise intensity had a significantly greater gain in endurance. The heart rate group had a mean increase of 6% (166 m) whereas the RPE group increased 11% (274 m). It is concluded that during aerobic dance the monitoring of exercise intensity with RPE is associated with greater improvement in endurance than is heart rate monitoring.

Keywords: Perceived exertion, heart rate, aerobic dance, fitness

Aerobic dance has become a popular form of exercise, and it is estimated that over 20 million Americans participate in this activity annually[1]. The intensity at which aerobic dance is maintained, as well as other forms of aerobic exercise, has traditionally been governed through the monitoring of heart rate. However, there are some reports in the literature suggesting that target heart rate may not be an accurate method of monitoring the intensity of aerobic dance[2]. It is also recognized that exercise heart rate can be influenced dramatically by various medications[3], psychological states[4], and environmental factors such as temperature and altitude[5].

Problems associated with the use of heart rate have led to the use of perceived exertion, in conjunction with heart rate, to estimate exercise intensity. It has been increasingly apparent that ratings of perceived exertion (RPE), as initially described by Borg[6], can be of considerable value in the testing and prescription of exercise. It is believed that RPE can assist in adjusting the intensity level to one that is both suitable for eliciting a training effect, as well as falling within a tolerable comfort zone. It has been found that RPE is not only related to the heart rate response at submaximal exercise levels, but also to other important measures of exercise strain such as lactate accumulation, core temperature, ventilatory minute volume, and glycogen depletion[7]. In fact, RPE has been shown to be a more accurate predictor of exercise capacity than heart rate[8,9].

In the American College of Sports Medicine (ACSM) *Guidelines for Exercise Testing and Prescription*[10], RPE is listed as a valid and reliable indicator of the level of physical exertion during endurance exercise. The ACSM guidelines actually state that 'RPE can replace heart rate as the primary means of monitoring exercise intensity in those participants who learn the relationship between RPE and heart rate' (p. 36). On the other hand, there is an absence of research comparing the effectiveness of RPE and heart rate monitoring in the regulation of acute exercise responses in the production of chronic training effects. Borg's theory of perceived exertion maintains that effort sense is a gestalt or configuration of many inputs, and therefore, RPE should always be a more accurate indicator of exercise strain than any single input variable such as heart rate. Also, monitoring of heart rate during exercise, either manually or by means of telemetry, tends to have a distracting influence. Hence, it was hypothesized that perceptual monitoring would be superior to heart rate monitoring in the development of endurance.

Methods

Subjects and design

A total of 76 female college students with a mean(s.d.) age of 20.0(4.0) years served as volunteers. The aerobic dance classes consisted of a 10-min warm-up period, followed by a 30-min aerobic section, and ended with a 10-min cool-down period. The classes were held twice a week and the training programme lasted 14 weeks. The distance covered during a 15-min run served as the dependent variable. Individuals in these classes were tested on the distance covered during a 15-min run at the

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beginning of the semester and then again 14 weeks later at the end of the semester. The independent variable was self-monitoring of exercise intensity. Thirty-eight students used heart rate to monitor exercise intensity during the 50-min aerobic dance classes. A target heart rate zone of 70–85% of the individual's heart rate maximum reserve was determined by using the Karvonen formula[11], and this training intensity was used during the 30-min aerobic section. Heart rate was counted for 10 s by palpating the carotid artery at 15 min into each exercise session, as well as after exercise. The target heart rate zone for these 38 students fell between 135 and 155 beats per minute. Thirty-eight additional students used ratings of perceived exertion to monitor exercise intensity during the aerobic dance class. Borg's 6–20 scale was used, and students were instructed to monitor their exercise intensity in order to produce an effort sense that would fall between 13 and 15 during the exercise. The verbal anchor for ratings of 13 and 15 corresponds to 'somewhat hard' and 'hard' respectively on this scale[5]. This RPE range has been found to approximate to 70–80% of maximal heart rate reserve[12]. Perceptual ratings were obtained 15 min into each exercise session, as well as following the 30-min session.

Results

The data were analysed with a repeated measures analysis of variance (ANOVA) for multifactor experiments[13] and this analysis indicated that the two groups did not differ significantly at the outset of training on the endurance measure. There was a significant trials effect ($F = 17.53$; $P < 0.0001$), as well as a significant interaction effect ($F = 5.64$; $P < 0.05$). A probe of simple main effects with a Newman Keuls post-hoc test revealed that both groups improved significantly in endurance performance during the 14 weeks of training and these results are depicted in *Figure 1*. The group using heart rate to monitor exercise intensity increased, during a 15-min run, from a mean(s.d.) of 2598(350) m at the beginning of the training period to a mean(s.d.) of 2764(340) m run at the end of the training period. The group using RPE to monitor exercise intensity increased from a mean(s.d.) of 2500(300) m to a mean(s.d.) of 2774(280) m for the same time period. An additional probe of simple main effects revealed that the group employing RPE to monitor exercise intensity had a significantly higher gain in endurance performance at the end of the training period than the group having heart rate monitoring. There was an 11% increase in endurance performance for the subjects using RPE to monitor exercise intensity compared with a gain of 6% for the group using heart rate monitoring.

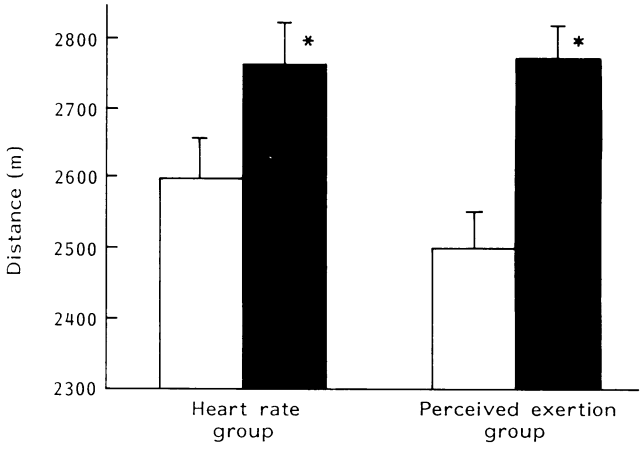

Figure 1. Mean(s.e.m.) changes in distance covered during a 15-min run in subjects in the heart rate and perceived exertion groups before (□) and after (■) 14 weeks of aerobic dance training. *$P < 0.001$

Discussion

Target heart rates have been used extensively to monitor exercise intensity during aerobic dance. However, it has been recognized that there are certain limitations with the use of heart rate monitoring. Environmental factors, psychological states and various medications have been shown to influence heart rate. Also, in a recent study by Parker *et al.*[2] it was reported that target heart rate may not be an accurate method of monitoring the intensity of aerobic dance. In this study, the heart rate responses to an aerobic dance training session were monitored and compared with the heart rate responses of treadmill jogging performed at the same $\dot{V}O_2$. There was a significantly higher heart rate response to aerobic dance compared with jogging. The investigators hypothesized that the higher heart rate response to aerobic dance may have been related to the large amount of arm work performed overhead. Åstrand *et al.*[14] have shown that arm work performed above the head produces a higher heart rate relative to $\dot{V}O_2$ than arm work performed below the head.

In the present study, the group that employed RPE to monitor exercise intensity had a significantly greater gain in endurance performance across 14 weeks of aerobic dance training than did the group that employed heart rate. One possible explanation for this finding may be that ratings of perceived exertion have been shown to represent a configuration of total bodily inputs[6]. That is, different factors, both physiological and psychological represent input variables which play a role in the formation of effort sense. Heart rate represents one component of this perception, whereas RPE is comprised of many inputs. It has been theorized by Borg[6] that RPE (the whole) will always be a more accurate indicator of strain than any single part (e.g. heart rate) of the whole.

Another possible explanation for the greater gain in performance in the RPE group was due to the fact that individuals in this group did not stop exercising in order to monitor exercise intensity. Training intensity can be accurately and continuously monitored throughout an entire exercise session where RPE is employed. In contrast, the group that employed heart rate monitoring in this investigation stopped exercising periodically in order to assess heart rate manually. This interruption of the exercise session may have reduced the overall training stimulus. Further research is needed with comparisons of RPE and heart rate in which heart rate is

monitored and displayed by means of telemetry. Also, future work needs to include continuous monitoring of heart rate in subjects who regulate exercise intensity on the basis of RPE alone. It is concluded that monitoring of exercise intensity with perceived exertion results in greater improvement in endurance performance than does heart rate monitoring during a 14-week programme of aerobic dance.

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References

1 International Dance Exercise Association (IDEA) Foundation. *Aerobic Dance-Exercise Instructor Manual.* San Diego: IDEA Foundation, 1987.
2 Parker SB, Hurley BF, Hanlon DP, Vaccaro P. Failure of target heart rate to accurately monitor intensity during aerobic dance. *Med Sci Sports Exerc* 1989; **21**: 230–4.
3 Van Camp SP. Health screening. In: Gelder NV, Marks S, eds. *Aerobic Dance-Exercise Instructor Manual.* San Diego: IDEA Foundation, 1987.
4 Morgan WP. Psychological factors influencing perceived exertion. *Med Sci Sports Exerc* 1973; **5**: 97–103.
5 Skinner JS, Hutsler R, Bergsteinova V, Buskirk ER. Perception of effort during different types of exercise and under different environmental conditions. *Med Sci Sports Exerc* 1973; **5**: 110–15.
6 Borg GAV. Psychophysical bases of perceived exertion. *Med Sci Sports Exerc* 1982; **14**: 377–87.
7 Pandolf KB, Cafarelli E, Noble BJ, Metz KF. Perceptual responses during prolonged work. *Perceptual and Motor Skills* 1972; **35**: 975–85.
8 Morgan WP, Borg G. Perception of effort in the prescription of physical activity. In: Craig T, ed. *Mental and Emotional Aspects of Sports.* Chicago: American Medical Association, 1976.
9 Wilmore JH, Roby FB, Stanforth PR *et al.* Ratings of perceived exertion, heart rate and power output in predicting maximal oxygen uptake during submaximal cycle ergometry. *Phys Sports Med* 1986; **14**: 133–43.
10 American College of Sports Medicine. *Guidelines for Exercise Testing and Prescription,* 3rd edn. Philadelphia: Lea and Febiger, 1986.
11 Karvonen M, Kentala E, Mustalof O. The effects of training on heart rate: a longitudinal study. *Ann Med Exp Biol Fenn* 1957; **35**: 307–15.
12 Pollock ML, Wilmore JH, Fox SM. *Exercise in Health and Disease.* Philadelphia: WB Saunders, 1984.
13 Winer BJ. *Statistical Principles in Experimental Design,* 2nd edn. New York: McGraw-Hill, 1971.
14 Åstrand I, Guharay A, Warren J. Circulatory responses to arm exercise with different arm positions. *J Appl Physiol* 1968; **25**: 528–32.