Comparative Analysis of Physical Static and Dynamic Exercises Using Borg's RPE 6-20 Scale

Yi-Lang Chen, Ping-Jui Yang, Chien-Chih Chen, Po-Yu Hsia, and Shih-Kai Lin

Abstract—**In this study, two physical exercises (dynamic running and static holding) were performed by 10 participants under 6 testing conditions of 3 load levels for each exercise. A good correlation was obtained between Borg's RPE 6-20 scale and the heart rates (HR) during dynamic exercises where the regression equation with an R-square was 0.712 (p<.001). The HR correlation was insignificant during static holding exercise (p>0.05). The finding suggested that caution should be considered when using HR as an indicator, because the body discomfort may be underestimated during locally static exercise.**

Index Terms—**Borg's RPE 6-20 scale, heart rate, dynamic and static exercise**

I. INTRODUCTION

BORG and Dahlstrom [3] defined these exercise-induced sensations as perceived exertion, and to optimize and monitor the training intensity of athletes, further developed a scale for rating perceived exertion (RPE). Distinct from other objective methods that measure physiological responses to assess exercise intensity, the RPE scale integrates various information including numerous signals elicited from the peripheral working muscles and joints, from the central cardiovascular and respiratory functions, and from the central nervous system. Currently, the RPE method has received widespread acceptance for obtaining a subjective estimate of work intensity, and as a means of monitoring and regulating exercise intensity across various populations [4]. This method can also be used in diagnostic situations, rehabilitation assessments, and in epidemiological evaluation of daily exercise intensities.

The original premise for the use of the RPE scale was its high correlation with HR. Numerous studies have employed the Borg RPE 6-20 scale as an indicator of physical strain (e.g., HR values) depending on gender [10], ethnicity [6], age [7], and exercise type [1]. The findings of these studies all show that significant correlation was found between HR and RPE values. Borg [2] and Eston and Williams [5] stated that when RPE values are greater than 15, higher exercise intensities induce the RPE to HR ratio to move closer to 1:10. However, Pollock [9] suggested that during exercise assessment the RPE prediction method for HR should be HR ≒ RPE × 10 + 20~30 (bpm) when the RPE values are between 11 and 16.

Although numerous studies on the applications of the Borg RPE 6-20 scale have been performed, studies that have used this scale to assess static and dynamic exercises are scant. In this study, we considered the relationship between RPE and HR during dynamic running and static holding for Taiwanese men.

II. METHODS

We recruited 10 male university students to participate in this study. The mean (SD) age, height, and weight of the participants were 23.5 (1.2) years, 171.3 (5.8) cm, and 67.0 (7.4) kg, respectively. All of them were no prior history of any musculoskeletal disorder and were paid and fully informed of the testing procedure, and full consent was obtained.

For dynamic exercise in the study, the participants ran on a treadmill (CS-5728, CHANSON, Taipei). The velocity settings for the treadmill were set at three load levels: 4, 8, and 12 km/hr. For the static exercise, the participants held a dumbbell in their dominate hand, and maintained their elbow at an angle of 90°, with the upper arm positioned vertically. The weight setting for the dumbbells were set at three load levels: 2.5, 5, and 6.5 kg.

The experimental tests comprised 6 experimental combinations (2 exercise types × 3 load levels). The duration of each exercise combination was 5 min, and the mean HR values were calculated for the last 30 s of each exercise. These HR values were adopted as the indicators for each combination, and the participants were asked to report the RPE value on Borg 6-20 scale (Table I) at the end of each exercise. The participants performed the various testing combinations in random order. Prior to the data collection, participants were familiarized with the Borg 6-20 scale and received standardized instructions that provided specific commands on how to implement the scale. A wireless HR monitor (Polar RS800CX, CHANSON, Taipei) was also attached to the participant's chest and the transmission readings were confirmed by an experimenter. To avoid the occurrence of carry-over fatigue, an interval of a minimum of 2 hr was set after every two exercise combinations.

The experimental data were analyzed using SPSS 17.0 with a significance level of 0.05. We analyzed the HR and RPE values of the two exercise types (i.e., dynamic and static)

Manuscript received December 12, 2012; revised January 07, 2013. This work was supported in part by funding from the National Science Council, R.O.C., grant no. NSC100-2221-E-131-026-MY2. This funding is gratefully acknowledged.

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ISBN: 978-988-19252-6-8
ISSN: 2078-0958 (Print); ISSN: 2078-0966 (Online)

at various load levels. Each participant was considered as one block. This study analyzed the HR and RPE data using an analysis of variance (ANOVA), and used Duncan's multiple-range test for post-hoc comparisons. Finally, we conducted simple regression analyses on the HR and RPE values of the various exercises, and formulated a regression equation that is suitable for Taiwanese men.

TABLE I
BORG'S RPE 6-20 SCALE AND ITS CHINESE DEFINITIONS

Scores	Perceived exertions	Chinese definitions
6	No exertion at all	一點也不費力
7	Extremely light	極度輕鬆
8		
9	Very light	很輕鬆
10		
11	Light	輕鬆
12		
13	Somewhat hard	有點困難
14		
15	Hard (Heavy)	困難
16		
17	Very hard	很困難
18		
19	Extremely hard	極度困難
20	Maximal exertion	已盡最大努力

III. RESULTS

Table II shows the results of the ANOVA and Duncan tests for the HR and RPE values of both exercises. The load variables of the different exercises significantly influenced the participants' HR and RPE values ($p<.001$). The results for the Duncan tests indicated that the RPE values for the both static and dynamic exercises revealed significant differences between any two load levels. This was also true for the HR values during the dynamic exercise. However, the greatest load levels for static exercises (i.e., 6.5 kg dumbbells for static holding) only significantly differed from the two lower loads. The HR values between the two lower load levels showed no differences.

TABLE II
THE TEST RESULTS FOR ANOVA AND THE DUNCAN TEST REGARDING THE MEAN (SD) RPE VALUES

	Heart rates (bpm)		Borg RPE 6-20 scale	
Exercises	Mean (SD)	Duncan groups	Mean (SD)	Duncan groups
Dynamic (*km/hr*)				
4	99 (11)	A	8.7 (1.6)	A
8	151 (13)	B	11.5 (1.2)	B
12	181 (11)	C	15.9 (2.0)	C
Static (*kg*)				
2.5	90 (11)	A	10.1 (2.2)	A
5.0	92 (13)	A	13.3 (2.0)	B
6.5	108 (13)	B	17.3 (3.5)	C

We obtained the HR regression equations for both exercise types by conducting a simple regression analysis. The result shows that the RPE values possessed significant prediction abilities for HR, and the variance explanatory power achieved 71.2% ($p < .001$). This result was consistent with the findings of Mark et al [8]. However, the RPE values for the static holding did not exhibit explanatory power ($p>.05$).

IV. DISCUSSION

In this study, we primarily explored the relationship between HR and Borg's RPE 6-20 scale values for Taiwanese men for both static and dynamic exercise types. When undertaking dynamic exercise, the HR and corresponding RPE values of the participants showed a significant correlation. These results are consistent with those proposed by Whaley et al. [10] and Eston and Williams [5]. However, the HR correlation was insignificant during static holding exercise. The finding suggested that caution should be considered when using HR as an indicator, because the body discomfort may be underestimated during locally static exercise.

As suggested by Pollock [9], the regression equation to predict participants' HR values using RPE scores should be revised to $HR = 10 \times RPE + 20 \sim 30$ (bpm) when the RPE values are between 11 and 16. During dynamic exercise (i.e., running on a treadmill), the regression equation obtained in this study to predict the participants' HR values was $HR = 8.92 \times RPE + 37.3$ (bpm). When the RPE value was between 11 and 16, the gap between the HR predicted by our regression model and $HR = 10 \times RPE$ ranged from 20 to 27 bpm; subsequently, the difference of the entire scale was between the range of 20 and 30 bpm, as shown in Fig. 1. The dynamic regression results of this study were consistent with those presented by Pollock [9].

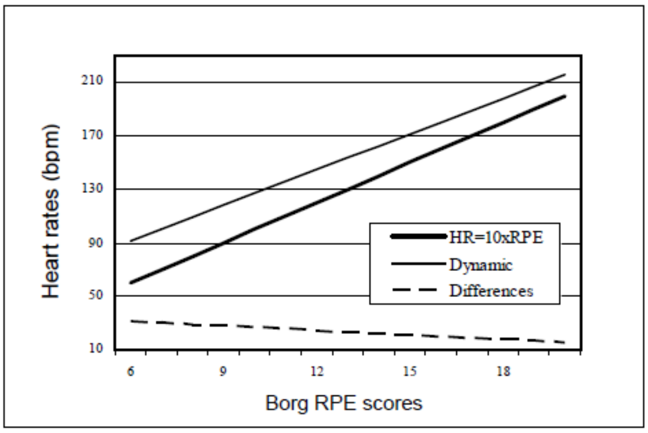

Fig. 1. The comparison between the HR regression line and HR = 10 x RPE under various exercise types

The results of this study showed that although static holding loads caused the participants' RPE scores to increase, the increase in HR was relatively less. Fig. 1 shows that even when the perceived exertion reported by the participant was an RPE score of 17 (very hard) or 19 (extremely hard), the corresponding HR value remained at approximately 110 bpm. Furthermore, we found that several of the participants reached an exhaustive state (RPE = 20, maximal exertion) when performing the heaviest loads, which indicated that HR values did not correctly reflect the perceived exertion of participants. During these conditions, contrary to the dynamic exercise, using HR values may critically underestimate perceived exertion.

V.CONCLUSION

This study examined the relationship between HR and Borg's RPE 6-20 scale values for Taiwanese men under both static and dynamic exercises. When performing dynamic exercise, the HR and the corresponding RPE values of the participants were significantly and positively correlative. However, The HR correlation was insignificant during static holding exercise. The finding suggested that caution should be considered when using HR as an indicator, because the body discomfort may be underestimated during locally static exercise.

REFERENCES

[1] D. R. Bouchard, and F. Trudeau, "Reliability of the assessment of the oxygen/heart rate relationship during a workday," *Applied Ergonomics*, Vol. 38, pp. 491-497, 2007.

[2] G. Borg, "Psychophysical bases of perceived exertion," *Medicine and Science in Sports and Exercise*, Vol. 14, pp. 371-381, 1982.

[3] G. Borg and H. Dahlstrom, "Psychophysical study of work on the bicycle ergometer," *Nordisk Medicine*, Vol. 62, pp. 1383-1386, 1959.

[4] R. Eston and D. Connolly, "The use of ratings of perceived exertion for exercise prescription in patients receiving beta-blocker therapy," *Sports Medicine*, Vol. 21, pp. 176-190, 1996.

[5] R. G. Eston and J. G. Williams, "Exercise intensity and perceived exertion in adolescent boys," *British Journal of Sports Medicine*, Vol. 20, pp. 27-30, 1986.

[6] R. W. Leung, M. L. Leung and P. K. Chung, "Validity and reliability of a Cantonese-translated rating of perceived exertion scale among Hong Kong adults," *Perceptual and Motor Skills*, Vol. 98, pp. 725-735, 2004.

[7] A. D. Mahon, K. Q. Stolen and J. A. Gay, "Differentiated perceived exertion during submaximal exercise in children and adults," *Pediatric Exercise Science*, Vol. 13, pp. 145-153, 2001.

[8] M. Mark, P. Sharon and W. Christine, "Using ratings of perceived exertion to reproduce blood lactate levels during a continuous exercise bout of varying intensities," *European Journal of Sport Sciences*, Vol. 2, pp. 1-11, 2002.

[9] M. L. Pollock, Prescribing exercise for fitness and adherence. In: R.K. Dishman (Ed.). Exercise adherence: Its Impact on Public Health. Champaign, IL: Human Kinetics Publishers, 1988.

[10] M. H. Whaley, M. T. Woodall, L. A. Kaminsky and J. D. Emmett, "Reliability of perceived exertion during graded exercise testing in apparently healthy adults," *Journal of Cardiopulmonary Rehabilitation*, Vol. 17, pp. 37-42, 1997.