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Original Article

Exercise regulation during cycle ergometry using Cantonese version of the CERT and Borg's RPE

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Abstract:

The purposes of the current study were (a) to assess the reliability of reproducing exercise intensity at a given effort rating during cycle ergometry using the Cantonese translated Borg's standard 6-20 rating of perceived exertion (RPE) scale and the 1-10 Children's Effort Rating (CERT) scale, and (b) to determine whether there is gender difference in the exercise responses at a given level of CERT or RPE ratings. Thirty boys and 30 girls aged 9-12 years were randomly assigned equally in gender to one of the following two groups: RPE and CERT. Each child performed two trials of four exercise bouts in either at CERTs 3, 5, 7 and 9 or at RPEs 8, 12, 15 and 18 in random order and on two separate days. Heart rate (HR), oxygen consumption (VO₂) and the final regulated power output (PO) at each rating level were measured. The results suggested that the boys and girls were able to comprehend both scales and use them to guide the regulation of exercise power output. The increase in power output reported by the children at each scale level coincided with the increase in power output regulated by the children, with concomitant increases in HR and VO₂ providing evidence that the children understood and were able to differentiate the concept of the scale level. This study was the first with the Cantonese translated RPE and CERT scales using production cycling protocol. The findings provided evidence for the validity of the Cantonese CERT and RPE scale.

Key Words: Children, exercise, rating of perceived exertion, children's effort of rating table

Introduction

Both the rating of perceived exertion (RPE) scale and the children's effort of rating table (CERT) have received considerably acceptance for use as a subjective mean to monitor and estimate or regulate the work intensity in a variety of settings across a variety of populations. The use of 6-20 RPE scale established by Borg (1985) in the exercise setting has included both an estimation paradigm, which is the quantification of the effort sense at a given level of exercise, and a production paradigm, which involves producing a given physiological effort based on an RPE value. Children between 8 and 12 years of age are able to estimate and produce 2-4 cycling intensities guided by their effort sense and distinguished sensory cues from different parts of their bodies. However, most of the studies reported that the exercise mode and the rating scale used could influence their perceptual responsiveness (Gros Lambert & Mahon, 2006). Researches related to the RPE with children in the past have addressed their accuracy in perceiving different levels of exercise intensities (Gros Lambert, Hintzy, Hoffman, Dugue, & Rouillon, 2001; Cowden & Plowman, 1999; Lamb, 1996) significantly positive correlations between subjective and objective measures of exercise intensity were evident with Pearson correlation coefficients which ranged from .45 to .88 among children (≥ 7 years old) in the incremental cycling exercise (Katsanos & Moffatt, 2005; M. L. Leung, Chung, & R. W. Leung, 2002; Alekseev, 1989; Gillach, Sallis, Buono, Patterson, & Nader, 1989; Eston & Williams, 1986; Bar-Or, 1977), treadmill exercise (Eakin, Finta, Serwer, & Beekman, 1992), and arm-cranking exercise (Bar-Or & Reed, 1986). Given its extensive research in the past two decades, it was deduced that the Borg scale was difficult to use in children. The validity and usefulness of RPE scale for children is dependent on age, reading ability, experience and conceptual understanding (Gros Lambert & Mahon, 2006).

Eston and colleagues (Williams, Eston, & Strech, 1991), in the early 90s proposed that a 1-10 scale (later named the CERT - Children's Effort of Rating Table) would be more appropriate for children, which led to a proliferation of interest and development of the CERT from the early 90's and into the late 2000. In the CERT, verbal expressions range from a limited number range of 1 to 10 which appears to be easier for children to understand (than 6-20) since it has five fewer responses than the RPE. Validity and reliability of the CERT as an indicator of exercise effort in children have also been confirmed by several studies (Lamb, 1996; Eston, Lamb, Bain, A. M. Williams, & J. G. William, 1994; Williams, Eston, & Furlong, 1994). Results showed statistically significant and positive correlations ($r_s = .69$ to $.99$) between the CERT and objective measures of exercise

intensity in children aged 5 to 9 years in incremental stepping exercise (Williams et al., 1994), and in children aged 8 to 11 years in incremental cycling exercise (Lamb, 1995; Eston et al., 1994).

Limited research has examined the ability of adolescents to produce a given exercise intensity based on perceived exertion. Production-mode research refers to studies in which children are asked to adjust the workload to different specifically perceived exertion levels (Eston, Parfitt, Campbell, & Lamb, 2000). The experimenter is instructed by children to vary the exercise intensities to achieve and maintain a given level of perceived exertion; then the objective indicators of effort (e.g., HR, PO, and VO_2) are measured. Hence, production-mode research therefore examines how children use perceptions of effort to self-regulate their exercise intensities (Ozkan & Kin-Isler, 2007; Wegner, Whaley, Glass, Kasper, & Woodall, 2007).

Misperception of the intensity of exercise during a bout of intermittent or continuous exercise is noticeable in children. Misperception of exercise intensity is common and may be a prime reason for children not to continue to exercise during a routine physical education class or physical recreation

activity. Because of the children's inept at regulating their efforts, they tend to work too hard, too soon.

Evidence for this phenomenon has been reported by Bar-Or (1989). Therefore if children are able to accurately self-regulate their exercise intensities in an organized schema, it would render a valuable tool for the children to have or learn to use the scale to gauge the intensity dimension of exercise, and to aid self-regulation of intensity during physical activity to produce the right exercise effort.

Both the CERT and RPE scale have received considerable attention cross culturally. In a landmark study conducted by Leung et al, 2002 ; R. W. Leung, M. L. Leung, Chung, & Quach, 2004; where the scales were translated into Cantonese. The authors reported acceptable validity and reliability of the Cantonese versions of the scales as measures of exercise intensity, noted that both studies used estimation protocol in their exercise designs. It appears that no production protocol studies have been conducted to examine the validity and reliability of the Cantonese versions of the CERT and RPE. To fill the gap, the present study aimed to assess the validity and reliability of the Cantonese-translated CERT and RPE as tools for children in regulating exercise intensity.

Material and Method

Participants

A total of sixty Hong Kong children (30 boys and 30 girls), aged 9 to 12 years, were recruited from local primary schools, and volunteered with parental permission to participate in this study. After being fully informed of the experimental procedures and possible discomfort associated with the exercise test, written informed consent was obtained from the children's guardians or parents. Ethical approval for this study was obtained from the Committee on the Use of Human and Animal Subjects in Teaching and Research of Hong Kong Baptist University. All the children could read and speak Cantonese fluently. The children were randomly assigned to one of the following two groups: RPE (15 boys, 15 girls) and CERT (15 boys, 15 girls). The test administrator informed both the children and their parents or guardians about the nature and procedures of the study. The parents or guardians were also required to complete the Physical Activity Readiness Questionnaire (PAR-Q) (Canadian Society for Exercise Physiology, 1994) on behalf of their children. If their parents or guardians reported any contraindication to the test, their children would be excluded from the study. The children's physical characteristics are showed in Table 1. No significant ($p > .05$) differences were observed between boys and girls in each experimental group

Procedures

Instructions on how to use the scales were both translated by a linguistic professional (permission for the translation of the CERT and RPE were fully detailed in Leung et al, 2002). The children reviewed both RPE and CERT scales numbers and the corresponding expressions in Cantonese carefully. It was emphasized to the children that the perceived effort referred to the overall whole-body exertion (undifferentiated RPE) and not just the partial fatigue coming from the legs, arms, or chest during the exercise test.

Each child performed three laboratory based exercise tests on two separate occasions (Trial 1 and Trial 2) of approximately one week apart. Trial 1 consisted of two tests. Test 1 was a PWC170 test and test 2 was a production mode test in which the children were required to self-regulate the exercise intensities i.e. power output at a given RPE or CERT rating. The PWC170 was performed and utilized as a sub- maximal index of aerobic fitness and also served as a familiarization to the exercise equipment.

All tests were performed on an electromagnetically braked cycle ergometer (Lode Excalibur Sport, Groningen, Netherland). Seat height and handle bar position were established and noted with the child in the most comfortable cycling position. The child was asked to maintain pedal cadence between 50-60 rev.min⁻¹. During the entire exercise test all information about exercise intensity i.e. heart rate and power output was concealed. The child was only allowed to see the cadence, which he/she was instructed to maintain within 50-60 rev.min⁻¹.

Pre-exercise resting HR and blood pressure (BP) of the participants were first measured and recorded.

Trial 2 was a repeat of trial 1 of test 2 and was conducted at the similar clock hours as trial 1 with the same children to control for physiological variation caused by circadian rhythms (Reilly, 2007). Both trials one and

two were carried out with the same test administrators. During the testing, the child was required to regulate the exercise intensities (i.e. PO) by adjusting the exercise workload to match a range of four scale-specific effort-rating levels randomly presented to the child. These were, 8, 12, 15 and 18 for (RPE); and 3, 5, 7 and 9 for (CERT). According to the study of Morris, Lamb, Cotterrell, & Buckley (2009) the random order of presentation could decrease the influence of immediate memory from the previous work rates. Trial 1 of the testing began with a 3-min, 25-Watts warm-up. After warm-up, the test administrator instructed the child to vary the cycling resistance based on the assigned perceived level. The display screen that specifies resistance (power output) was masked from the child all the times. The child was allowed 2 min to achieve the perceived power output by increasing or decreasing the workload from the control unit, corresponding to their RPE or CERT and then further cycling for another 2 min at that power output to complete each stage. Oxygen consumption and heart rate were measured continuously during the duration of each exercise bout via breath-by-breath online gas analysis (Sensormedics Vmax 229d, Yorba Linda, CA), and Polar wireless telemetry (Polar, RS400). Power Output regulated by the child was then recorded for data analysis during the last 15s of each RPE or CERT level. The child was given a 2-4min rest period between exercise levels. If the child could not keep up with the work rate for 30s, testing would be terminated. In the recovery periods, HR and BP of each participant were monitored until they returned to the pre-exercise values. Those who cannot complete at least three levels of the testing were excluded from the study.

Data analysis

Power output, heart rate and VO_2 were analyzed with a mixed model (Trial [2] x Level [4] x Gender [2]) analysis of variance (ANOVA). The assumption of sphericity will be checked using the Mauchly test, and where necessary, the Greenhouse-Geisser adjustment will be applied to the analysis of variance. Post hoc analyses with Tukey HSD test were performed when main effects of ANOVA were significant. Intraclass correlation coefficient (ICC) procedures across two trials were applied to assess the reliability of the children to reproduce the effort. All tests for statistical significance were set at an alpha level of $p < 0.05$, and all results are expressed as mean+s.

Results

Rating of perceived exertion scale

For PO (W), the main effects for Trial ($F_{1, 112} = 4.162$ $p < 0.05$) and Gender ($F_{1, 112} = 13.768$ $p < 0.05$) were significant. The PO value in Trail 2 (44) was significantly higher than that in Trail 1 (40.9) and the PO value for boys (49.4) was significantly higher than that for girls (35.6). Significant main effect for RPE level ($F_{3, 112} = 40.746$ $p < 0.05$) was also found. Post hoc comparisons using the Tukey HSD indicated that the mean PO increased significantly between RPE8 (15.1), RPE12 (33.2), RPE15 (51.1), and RPE18 (70.5), which provided the evidence that the children could understand the concept of the scale and were able to guide their exercise efforts according to the different rating scale levels. For HR (beat.min-1), the main effects for Trials and Gender were not significant. However, main effect for RPE Level was significant ($F_{3, 112} = 67.382$ $p < 0.05$). Post hoc analysis revealed that the mean heart rate increased significantly with each increasing in RPE level (RPE8=110; RPE12=125; RPE15=139; RPE18=155). For VO_2 (L.min-1), no significant main effect was found for Trial. There were significant main effects for Gender ($F_{1, 112} = 20.388$ $p < 0.05$) and RPE Level ($F_{3, 112} = 27.842$ $p < 0.05$). The mean VO_2 for boys (0.65) was significantly higher than girls (0.46). For RPE level, post hoc analysis revealed that the mean VO_2 also increased significantly with each increasing in RPE level (RPE8=0.30, RPE12=0.47, RPE15=0.63, RPE18=0.84).

Children exertion rating table

For PO (W), main effect for Gender was not significant. But main effects for Trial ($F_{1, 112} = 16.063$ $p < 0.05$) and CERT Level ($F_{3, 112} = 47.408$ $p < 0.05$) were significant. The mean PO value in Trail 2 (51.8) was significantly higher than that in Trail 1 (46.3). Post hoc analysis revealed that the mean PO increased significantly with each increasing in CERT level (CERT3=23.0, CERT5=42.2, CERT7=56.9, CERT9=75.0), which provided the evidence that the children are able to understand the concept of the scale. Unexpected, the interaction for Trial x Level x Gender was significant ($F_{3, 112} = 3.004$ $p < 0.05$) was detected.

For HR (beat.min-1), no significant main effect for Trial was revealed. However, main effects for Gender ($F_{1, 112} = 6.345$ $p < 0.05$) and CERT level ($F_{3, 112} = 40.317$ $p < 0.05$) were found. For Gender, girls' mean HR value (143) was significantly higher than that for boys (136). Post hoc analysis revealed that the mean HR also increase significantly with each increasing in CERT level (CERT3=117, CERT5=134, CERT7=146, CERT9=161), which provided evidence that the children understood the concept of the scale.

For VO_2 (L.min-1), no significant main effect was found for Gender. However, main effects for Trial ($F_{1, 112} = 6.776$ $p < 0.05$) and CERT level ($F_{3, 112} = 33.933$ $p < 0.05$) were significant. The mean $VO_{2\text{ in Trail 2}}$ (.64) was significantly higher than that in Trail 1 (.59). Post hoc analysis revealed that mean VO_2 was significantly higher with each increasing in CERT level (CERT3=0.36, CERT5=0.54, CERT7=0.68, CERT9=0.86).

Intra-class correlation coefficient

To test the consistency of the children in reproducing the effort (PO), intra-class correlation coefficient (ICC) procedures across the two trials were applied to each of the objective measures (Table 3). Overall, the ICC was high, ranging from 0.90 to 0.94 for the two groups. When results were analyzed at each rating level, the coefficients (r) were generally lower than those for the overall data. Across different rating levels for the two scales, the test reliability showed more consistencies in girls. With boys showed inconsistent at RPE level 8 and CERT level 5, with rs of 0.56 and 0.57, respectively.

Discussions

The purpose of the current study was to examine children's abilities in using the Cantonese translated versions of the CERT and RPE to regulate their exercise intensity. Results showed that children were able to comprehend both scales and use them to guide the regulation of exercise intensity. The increase in power output reported by the children (15, 33, 51, and 70W at RPE 8, 12, 15, and 18, respectively) and (23, 42, 57 and 75W at CERT 3, 5, 7 and 9, respectively), provided evidence that the children understood and were able to differentiate the concept of the scale level. To further support this notion both HR and VO_2 also showed a concomitant increases with each increment in rating level for both CERT and RPE scales.

The main effect for trial on power output for both CERT and RPE can be explained by the children's underestimation of the effort in trial 1. Trial 2 consistently received higher mean PO than Trial 1 but only at CERT 3, 5 with a mean different of +2.7W, +8.3W (boys) and +9.2W, +10.3W (girls), respectively, and RPE 8 and 12 with a mean different of +3.9W, +5.6W (boys) and +6.4W, 6.4W (girls), respectively. However, as rating level increases to CERT 7, 9 and RPE 15 and 18, these discrepancies in mean power output between trials were apparently attenuated.

In the RPE group, the main effect for Gender on power output revealed that boys recorded a higher power output across all RPE levels can be explained by the motivational oriented nature of boys. For example, Duda and colleagues (Duda, Chi, Newton, Walling & Catley, 1995) reported that boys are more ego-orientated than girls. Ego-oriented individuals are more concerned with demonstrating their ability to others rather than the completion of the task demands. Consequently, in this context, ego- oriented individuals would be likely to produce higher power outputs at each RPE level to demonstrate their physical abilities to the experimenter (Eston, Parfitt, Campbell, & Lamb, 2000). Another explanation might be that boy is more superior at estimating their absolute exercise workload (i.e. PO) as boy would be more physically active or girls may have underestimated their exercise workload as girls are seen to be habitually less active than boys, thus their perceptions of effort might have been less attuned comparing to boy (Lamb, 1995). Fitness level may play a role, results of analysis revealed no significant main effect for gender and trials on heart rate. Table 2 revealed that at equivalent rating level girl's self-regulated workload (PO) were significantly lower than that of boys. Previous research has indicated that boys participated in more exercise than girls (Fu, 1993; To, 1985). Culturally, Hong Kong girls tend to be passive and introverted and typically are less active than boys (Ng, 1995; Fu,

1993). To (1985) stated that the higher participation in exercise by boys enhanced their fitness and resulted in better performance on fitness tests. Thus sex differences in relation to habitual participation in exercise might affect the perception of effort during exercise.

In contrast, the CERT group, analysis revealed main effect for gender on power was not significant, where boys and girls recorded no significant different in power output across the four CERT levels. However, the significant interaction for trial x level x gender was probably due the large mean different occurred at CERT level 9 between trial 1 and trial 2 for boys, where boys reported a mean different

between T2-T1 of 12.5W as compared to girls of -1.8W. High overall reliability of reproducing exercise intensity (PO) (ICCs = .90 to .94) was observed in both the CERT and RPE groups. The ICCs in the RPE group rose with increase of the RPE level, suggesting that the production of relatively higher exercise intensities appeared to be easier for this age group to reproduce. Boys showed slightly more stable reproductions of PO at the same RPE levels than girls except at RPE 8 where the ICC was only 0.56 (n.s). This was due to a significantly ($p < .01$) higher PO that was produced by boys. One explanation for this could be the children may have difficulties trying to interpret the verbal expression of RPE level 8 of extremely light (in Cantonese). Interestingly girls seem to be more stable at reproducing PO in the CERT scale, whereas there were inconsistencies shown in boys at CERT 5 where the ICC was only 0.57 (n.s). For the RPE scale, reproducing PO at higher RPE levels appeared to be more reliable for children than at lower RPE levels. However, this was not the case for the CERT scale. Only the ICCs of HR in the CERT group showed a trend that they rose with the increase of the CERT level.

Although the current study showed that the Cantonese CERT and RPE are valid and reliable tools for children to produce exercise intensity, its uses can only be applied to cycle ergometry and lab setting since most of the research testing was performed in a controlled laboratory condition. The production mode that used in this study was a structured tasks, however, these tasks usually do not translate into a

normal, less structured play activity of children for example during PE classes. The usage in field settings deserves further attention and consideration. Ceci and Hassmén (1991) found that there were large mean differences in the objective variables (i.e., HR and blood lactate etc.) between field and laboratory settings. Another study conducted by Cowden and Plowman (1999) in a field setting found that children did not respond consistently to their physical feedback and their understanding of abstract concepts and integrating abstract reasoning into action did not develop until around the age of 11 years. This might be related to the use of different exercise modes, ranges of the rating scale, age ranges, and their different testing environments. Further studies could be conducted.

Conclusions

The result of this study demonstrates that the Cantonese versions of the CERT and RPE appear to be reliable and valid for children to regulate exercise intensity, basis on the ability of the boys and girls able to differentiate the different level of rating. However, it fails to confirm both boys and girls were able to reproduce on a consistent basis. From the data view point girls seem to show more consistencies across the 4 levels of both CERT and RPE scales. The consistency may be able to be improved through more practice and reinforcement. Evidence for this phenomenon was reported by Eston et al. (2000), in which they confirmed that the reliability (ICC) could be improved by practice. Further research in regard to the use of the scales in field settings and gender differences in the interpretation of the two scales seems warranted.

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Appendix

Table 1
Physical characteristic of the participants

Measure	RPE Group			CERT Group		
	Girls (n = 15)	Boys (n = 15)	All (N = 30)	Girls (n = 15)	Boys (n = 15)	All (N = 30)
Age (yr)	10.9 (1.0)	11.0 (1.0)	11.0(1.1)	10.9(1.0)	10.6(0.90)	10.8(1.0)
Height (cm)	147.0 (10.9)	143.5 (6.2)	145.2(8.9)	140.7(8.9)	144.9(10.3)	142.8(9.7)
Mass (kg)	41.6(10.4)	35.4(6.8)	38.5(9.2)	33.7(7.6)	38.5(10.3)	36.1(9.2)
BMI (kg/m ²)	17.1(2.2)	19.0(3.4)	18.1(3.0)	18.0(2.7)	16.8(1.9)	17.4(2.4)

Note. Value in mean +s; BMI = Body Mass Index.

Table 2

Mean power output (PO), heart rate (HR) and oxygen consumption (VO₂) for each scale rating level across the two trials.

Variable	All			Boys			Girls		
	PO (W)	HR (beat/min)	VO ₂ (l/min)	PO (W)	HR (beat/min)	VO ₂ (l/min)	PO (W)	HR (beat/min)	VO ₂ (l/min)
RPE Scale									
RPE = 8									
Trial 1	12.5(11)	109.0(14)	.29(.15)	14.7(13)	106.5(17)	.33(.18)	10.3(7)	111.1(9)	.26(.10)
Trial 2	17.7(11)	111.2(12)	.30(.14)	18.6(10)	110.8(13)	.34(.16)	16.7(11)	111.6(12)	.27(.13)
RPE = 12									
Trial 1	30.2(17)	124.0(11)	.43(.17)	34.7(15)	123.1(7)	.47(.18)	25.7(18)	124.7(15)	.39(.20)
Trial 2	36.2(19)	127.1(18)	.50(.24)	40.3(19)	129.1(21)	.59(.30)	32.1(18)	125.0(15)	.42(.15)
RPE = 15									
Trial 1	51.2(24)	140.8(16)	.63(.30)	60.5(26)	143.1(15)	.75(.31)	41.9(20)	138.5(17)	.53(.26)
Trial 2	51.1(30)	137.9(18)	.61(.34)	61.5(37)	141.5(21)	.75(.41)	40.6(16)	134.3(16)	.49(.17)
RPE = 18									
Trial 1	70.0(29)	155(15)	.83(.37)	81.6(34)	159.2(14)	1.0(.42)	58.3(18)	150.8(15)	.66(.19)
Trial 2	71.0(31)	154(16)	.85(.36)	83.1(36)	158.1(14)	1.0(.40)	58.9(22)	150.1(17)	.68(.22)
CERT Scale									
CERT = 3									
Trial 1	20.1(13)	117.3(15)	.35(.15)	22.1(14)	114.7(16)	.35(.12)	18.1(13)	120(16)	.35(.18)
Trial 2	26.0(14)	116.9(14)	.38(.16)	24.8(12)	112.5(11)	.34(.14)	27.3(17)	121.3(16)	.41(.18)
CERT = 5									
Trial 1	36.5(15)	130.8(19)	.49(.17)	34.7(14)	123.1(18)	.47(.16)	38.4(16)	138.4(17)	.50(.18)
Trial 2	45.9(16)	137.2(19)	.59(.17)	43.0(16)	130.2(21)	.59(.17)	48.7(16)	144.3(15)	.62(.17)
CERT = 7									
Trial 1	56.2(18)	147.9(20)	.68(.24)	59.2(18)	147.9(19)	.69(.24)	53.2(18)	149.8(18)	.66(.24)
Trial 2	57.6(18)	145.6(18)	.69(.21)	58.1(16)	145.6(18)	.69(.21)	57.1(20)	149.8(18)	.71(.24)
CERT = 9									
Trial 1	72.5(23)	161.7(21)	.84(.30)	72.5(23)	161.7(20)	.82(.29)	72.1(25)	166.1(16)	.86(.31)
Trial 2	77.6(28)	161.7(20)	.88(.31)	85.0(30)	163.9(19)	.88(.31)	70.3(26)	159.5(20)	.83(.31)

Note. Value in mean + s

Table 3

Overall and Individual Intraclass correlation (ICC) for dependent variables at each scale rating level for boys and girls across two trials.

	Scale - Level	Boys			Girls		
		PO	HR	VO ₂	PO	HR	VO ₂
RPE	RPE=8	0.56*	0.69	0.72	0.64	0.63	0.78
	RPE=12	0.84	0.44*	0.81	0.72	0.18*	0.86
	RPE=15	0.82	0.37*	0.87	0.82	0.67	0.74
	RPE=18	0.93	0.58	0.92	0.84	0.76	0.90
	Overall (n=60)	0.94	0.85	0.93	0.90	0.83	0.90
CERT	CERT=3	0.74	0.64	0.55*	0.92	0.69	0.84
	CERT=5	0.57*	0.65	0.46*	0.70	0.68	0.76
	CERT=7	0.78	0.88	0.71	0.64	0.57*	0.78
	CERT=9	0.89	0.91	0.64	0.93	0.79	0.90
	Overall (n=60)	0.92	0.90	0.83	0.91	0.84	0.90

Note. *p > 0.05 ; PO = Power Output, HR = Heart Rate, VO₂= Oxygen Consumption