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ORIGINAL ARTICLE

# Assessment of EPInfant scale for exercise intensity perceptual self-regulation in healthy children

## Evaluación de la escala EPInfant para la auto-regulación perceptual de la intensidad del ejercicio en niños sanos

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### Abstract

**Introduction:** The EPInfant scale has been validated for the perceptual estimation of physical exertion in Chilean children, but its usefulness for self-regulation of exercise intensity is unknown. The objective of the study was to evaluate the criterion validity of the EPInfant scale to regulate and reproduce exercise intensity in a sample of healthy children. **Subjects and Method:** 15 children between the ages of eight and 12 were selected for an incremental exercise test (IET) and three perceptually regulated exercise tests (PRET) on a treadmill. The tests were performed with a 48-hour interval between them. In the PRET, the exercise load was adjusted perceptually for five minutes, randomly considering levels 3, 6, and 9 of the EPInfant scale. The average heart rate (HR) during PRET was considered as the perceptually reproduced intensity. Variance analysis, simple linear regression, and reliability analysis were used to determine the reproducibility of HR during PRET. **Results:** There was a significant difference in HR between perceptual levels during PRET ($p < 0.001$). Additionally, a correlation was observed between HR during the IET and the PRET ($r = 0.83$, $r^2 = 0.69$). The intraclass correlation coefficient was 0.76, 0.83. and 0.93 at perceptual levels 3, 6, and 9; and the mean discordance between HR during the IET and the PRET was -2.4 beats/min. **Conclusion:** In the studied sample, the EPInfant scale was valid to allow the perceptual regulation and reproduction of exercise intensity in a treadmill.

**Keywords:**
Children;
Physical exertion;
Exercise;
Perception;
EPInfant scale;
Validity

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## Introduction

The perceived exertion (PE) is the sensations set partly caused by metabolic changes during exercise. Several studies have shown a strong association with heart rate (HR), oxygen consumption ($VO_2$), and blood lactate during physical exercise (PhE) in healthy children[1].

The PE is used as a physiological stress estimator produced by a given exercise load which corresponds to a paradigm called "*estimation*". In this paradigm, PE behaves as a dependent variable, and changes in exercise load, HR and/or $VO_2$ correspond to independent variables, which are autogenously regulated or externally dosed[2].

In addition to PE studies using the estimation paradigm, in recent years there has been a growing interest in studying the validity of these scales as instruments aimed at perceptually self-regulating the intensity of PhE[3]. This paradigm is called "*estimation-production*", in which the PE is used to predetermine the intensity interval at which a given PhE should be executed[2]. Although evidence supports the use of PE through this paradigm in the adult population[3], there are few studies with contradictory results in the pediatric population[4-6]. Probably due to the effective use of PE under this paradigm implies both the memorization of PE during PhE and the reproduction of the exercise load (previously experienced) in a subsequent PhE session, which is closely dependent on the cognitive development of the child and/or adolescent[2,7].

In Chile, the perceived exertion scale for children "EPInfant" has shown a strong validity and reliability for the physiological stress estimation in children from 8 to 15 years old in different PhE modalities[8]. However, its validity and eventual usefulness for using it through the estimation-production paradigm in children is unknown to date. For this reason, the objective of this study was to assess the EPInfant scale criteria validity for self-regulation and reproduction of exercise intensity in healthy Chilean children.

## Subjects and Method

### Design

A quasi-experimental crossover study[9] was carried out to determine the self-regulating capacity of the PhE intensity through a perceptual regulation test. Figure 1 shows the general outline of the study design.

### Study subjects

Healthy volunteers between 8 and 12 years old were selected from a public school in Talcahuano, Chile. The presence of a neurocognitive, skeletal, neuromuscular or chronic cardiorespiratory disease was considered as an exclusion criterion, as well as the regular practice of some sport. In addition, children with obesity defined according to WHO criteria[10] were excluded. The exclusion criteria were established through a checklist completed by the child's parent.

The parents signed an informed consent form and the children signed an assent form. The study was approved by the scientific ethics committee of the University of Concepción, Chile.

For the sample size estimation, the PE ability to discriminate physiological stress during the PhE was considered. For this, the validity studies result previously carried out by our group were used[11]. Thus, the average HR difference between perceptual levels 3, 6 and 9 of the EPInfant scale (22.5 beats/min) and a 17.2 beats/min standard deviation were considered for the calculation. Therefore, accepting a 5% alpha error risk and 20% beta error, the estimated number of subjects was 14 (7 boys and 7 girls).

### Experimental protocol

The protocol was carried out in four sessions with an interval of 48 hours between each session (Figure 1).

In the first session, training on the use of the EPInfant scale was carried out through the recommendations published by Rodríguez et al[12]. In addition, weight, height (ADE M318800), and blood pressure (Omron HEM-742int) were measured, and an incremental exercise test (IET) was performed on a treadmill (h/p/cosmos mercury®). During the IET, the PE was used to estimate the physical effort perception produced by the exercise load executed during the IET (estimation paradigm).

During the following three sessions, a perceptually-regulated exercise test (PRET) was carried out where the PE was used to regulate the PhE intensity through the estimation-production paradigm. The PE was measured by the same evaluator in all sessions. The protocol was carried out in the exercise physiology laboratory of the Universidad Santo Tomás (Concepción, Chile).

### Incremental exercise test

Before the IET, participants got familiar with the treadmill and rested for 20 minutes, where the resting HR (polar® R800i) and PE (EPInfant) were recorded.

The IET was carried out according to the protocol published by Utter et al[13], which has 10 incremental intensity levels, with an initial 4.0 km/hr speed for 3 minutes and 0.8 km/hr increments every 2 minutes until reaching an 8.8 km/hr speed. From this speed, the inclination increases 3% every 1 minute, until reaching a 12% inclination in the last level. During the test, the HR and PE were recorded at each stage.

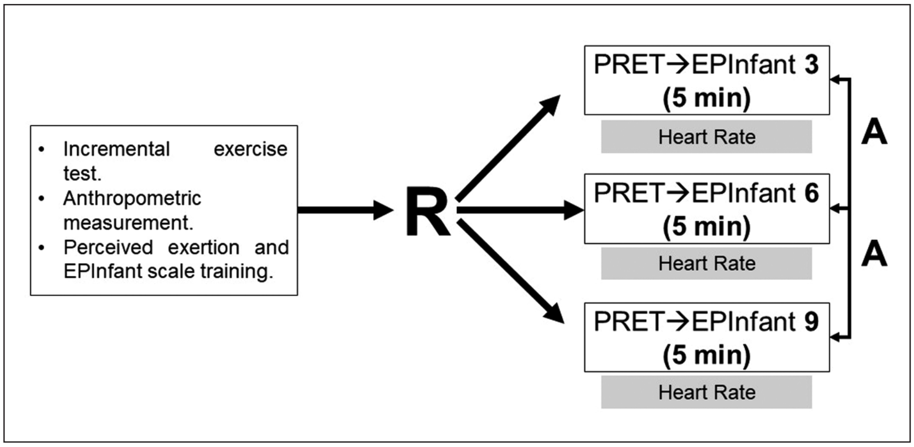


**Figure 1.** Study design. The study was performed in 4 sessions. First, general variables were assessed, EPInfant scale was explained and IET was performed. Later, the intensities for PRET were stated randomly. After that, 3 PRET were performed in non-consecutive days, considering the perceptual loads 3, 6 and 9, according to EPInfant scale. During PRET the heart rate was recorded during 5 minutes. The mean heart rate during PRET was considered for statistical analysis.

**Perceptual regulation test of exercise intensity**

The PRET was initiated using the same incremental intensities sequence of the IET, however, the maximum exercise load reached was established perceptually, considering the value 3, 6 or 9 of the EPInfant scale. Only one perceptual level was used per session and the sequence was established randomly. The equivalent exercise load to the perceptual level was kept constant for five minutes and the HR was recorded every one minute. The average HR during this period was considered as the magnitude of the intensity reproduced perceptually during the PRET (Figure 1).

**Table 1. General characteristics of the study sample and physiological response during IET**

| Variables | Mean ± SD |
|---|---|
| General Characteristics | |
| Gender (n men/female) | 8/7 |
| Age (Years) | 9.8 ± 1.4 |
| Weight (kg) | 38.2 ± 6.9 |
| Height (m) | 141.1 ± 9.4 |
| BMI (kg/m$^2$) | 19.1 ± 2.0 |
| BMI/Age relationship (percentile) | 81 (46 – 93)* |
| Rest SP (mmHg) | 98.5 ± 13.5 |
| Rest DP (mmHg) | 60.9 ± 11.3 |
| Rest $O_2$ Saturation (%) | 98.9 ± 0.3 |
| Physiological response during IET | |
| Rest HR (Beat/min) | 83.9 ± 9.3 |
| HR max. (Beat/min) | 201.2 ± 0.87 |
| HR Peak IET (Beat/min) | 183.1 ± 15.5 |
| Rest PE | 1.0 (0 – 1) |
| Maximal PE | 10.0 (10 – 10) |

BMI: Body max index; SP: Systolic pressure; DP: Diastolic pressure; HR: Heart rate; HR: Heart rate; IET: Incremental exercise test; PE: Perceived exertion. *Results is shown in median and range (minimum-maximum).

**Statistical analysis**

Normality was verified using the Shapiro-Wilk test, followed by descriptive statistics using the mean and standard deviation calculation for quantitative variables, and median and interquartile range for qualitative variables.

The comparison between perceptual levels 3, 6 and 9 during the PRET was done using an Analysis of Variance (ANOVA) for repeated measures, where the HR was compared. In addition, the T-Test for paired samples was used to compare the HR between the IET and the PRET at each perceptual level, and also, the HR intraclass correlation coefficient (ICC) between the IET and the PRET was calculated at each perceptual level.

The interdependence between the estimated and reproduced HR during the IET and the PRET was determined by simple linear regression, considering the HR during the IET as an independent variable and the HR during the PRET as a dependent one. Finally, the mean discordance, as well as the discordance limits with a 95% Confidence Interval (95% CI), between the HR measured during the IET and the PRET were verified using the Bland-Altman plot.

Statistical analysis was performed using the MedCalc statistical software version 18.6 (MedCalc Software bvba, Ostend, Belgium, 2018) considering a $p < 0.05$ value as statistically significant.

## Results

The study included 15 children (8 boys and 7 girls), average age of 9.8 ± 1.4 years. The maximum HR achieved during the IET was 183.1 ± 15.5 beats/min (91.0 % of the theoretical maximum HR). The maximum PE was 10 points (Table 1).

**Table 2. Reliability of heart rate during IET and PRET in perceptual levels 3, 6 and 9**

| Niveles perceptivos | FC durante el TCI | FC durante la PRP | CCI (95%IC) |
|---|---|---|---|
| PE 3 | 136,1 ± 16,6 | 141,0 ± 17,5 | 0,76 (0,20 - 0,93) |
| PE 6 | 161,4 ± 18,5 | 163,5 ± 19,2 | 0,83 (0,39 - 0,95) |
| PE 9 | 181,3 ± 16,4 | 176,2 ± 13,3 | 0,93 (0,64 - 0,98) |

PRET: Perceptual regulation test of exercise intensity; IET: Incremental exercise test; HR: Heart rate; ICC: Intraclass correlation coefficient; CI: Confidence interval; PE: Perceived exertion. Quantitative variables are shown in mean and standard deviation. There was statistical difference in the HR between each perceptive level during the PRET (PE3 < PE6 [p < 0,0001] y PE6 < PE9 [p < 0,0003]).

Table 2 shows the HR at each perceptual level. There was no statistically significant difference between IET and PRET in the studied perceptual levels. However, there was a difference in HR between PE 3 and 6 (Δ16.0%; *Bonferroni post-hoc test*, p = 0.0001), and between PE 6 and 9 (Δ7.8%; *Bonferroni post-hoc test*, p = 0.0003) during the PRET. Additionally, the ICC calculated for HR between the IET and the PRET was 0.76, 0.83 and 0.93 for perceptual levels 3, 6 and 9 respectively (Table 2).

The regression model was statistically significant for the determination of HR during PRET, based on HR estimated during IET (F-ratio = 61.74; p = < 0.0001). The correlation coefficient between HR measured during the IET and the PRET was r = 0.83 ($r^2$ = 0.69) (Figure 2).

Also, the Bland-Altman plot revealed that the mean HR discordance between the IET and the PRET was -2.4 beats/min and the discordance limits (95%IC) were 23.9 beats/min and -28.7 beats/min (Figure 3).

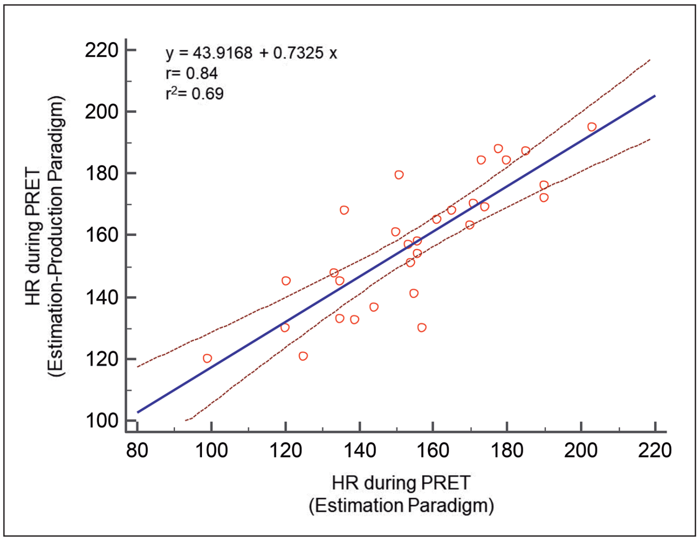


**Figure 2.** Linear regression between produced heart rate (HR) during PRET and estimated HR during IET (incremental exercise test).

## Discussion

This study is the first to examine the EPInfant scale validity for its application through the estimation-production paradigm. Its general results confirm its usefulness for perceptual self-regulation of exercise intensity in children between 8 and 12 years of age.

In our protocol, perceptual reproduction capacity was evaluated through a uni-modal approach, by comparing the estimated and reproduced HR at perceptual levels 3, 6 and 9 of the EPInfant scale. Perceptual levels were randomly assigned during the PRET in order to minimize the risk of bias attributed to perceptual pre-programming in the exercise loads progression developed in consecutive sessions[14,15]. Thus, the results revealed that individuals were able to effectively reproduce HR during PRET at the 3 perceptual levels (3, 6, and 9), showing a low mean discordance (2.4 beats/min) with HR measured during the estimation trial (IET).

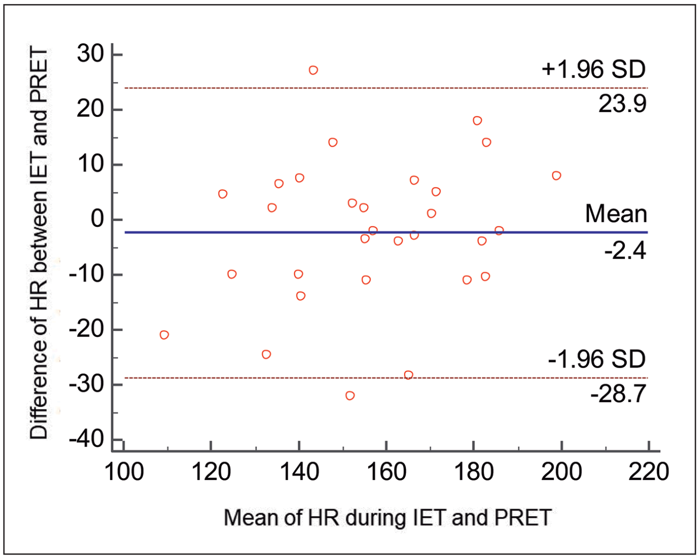


**Figure 3.** Bland-Altman Analysis of reliability of exericise intensity during PRET. IET: Incremenal exercise test.

Although several authors assert that from seven years of age (concrete operational stage according to Piaget) children could effectively use PE through the estimation paradigm, the evidence has been contradictory regarding the estimation-production paradigm, because the reproduction of exercise intensity from PE demands the mastery of more complex cognitive skills that require a high level of memorization and the integration of perceptual/psychological, physiological and situational dimensions[7,16]. Interestingly, in our study, the linear regression analysis revealed that the PhE intensity reproduced during the PRET was determined at 69% by the pre-experienced exercise loads during the IET ($r^2 = 0.69$), which allows inferring that the children were able to retain, by more than 50%, the physiological stress intensity perceived during the first PhE experience.

These results are consistent with some similar studies previously conducted in children between 5 and 11 years of age. Parfitt et al. evaluated the usefulness of two pediatric scales (CALER and BABE) for self-regulation of PhE intensity in cycle ergometer and step board in healthy children between 7 and 11 years old, considering perceptual levels 3, 5 and 8 in both scales. In their study, the magnitude of the global difference between estimated and reproduced HR ranged from -4 to 7 beats/min and the reliability between the HR of both paradigms was moderate to strong, increasing at the highest perceptual levels[15]. Groslambert et al. studied in children between 5 and 7 years old their ability to self-regulate the exercise intensity through an estimation test during a race along an empty hallway, considering perceptual levels 2, 6 and 10 of the OMNI scale. Their results showed a global difference ranging from 1 to 3 beats/min between estimation and production trials[6].

The perceptual levels considered in our study have demonstrated to be equivalent to low (PE 3), moderate (PE 6), and high (PE 9)[11] PhE intensities, which was confirmed in this study when intensities equivalent to 44.5%, 66.1%, and 83.0% of the reserve HR respectively were recorded. Additionally, it was possible to verify that the reliability magnitude in the reproduction of PhE intensity was grater at higher perceptual levels, with calculated ICC of 0.76 for perceptual level 3 and 0.93 for perceptual level 9; which is closely in line with previous studies where it has been shown that PE levels lower than 5 are more difficult to reproduce compared to higher perceptual levels during a PRET[5,17].

On the other hand, in the Bland-Altman plot, wide discordance limits were reported (23.9 to -28.7), which do not allow to discard the existence of variability in the perceptual reproduction of the PhE. This is consistent with the study by Erichsen et al., who recently observed in 12 children (7 to 9 years old) a high variability in physiological response during a PRET[18]. Consequently, if this phenomenon is attributed to the small sample size of the studies or to possible factors associated with the nature of the perceptually regulated physiological response in children, it should be explored in further studies.

This study presents certain limitations that must be analyzed. First, the PRET had a short duration (5 minutes), therefore, our results do not allow us to confirm or rule out that in longer reproductive trials there may be a higher discordance between the estimated and reproduced intensity, as has been suggested in studies with adult population[19-21].

On the other hand, it is important to mention that in this study a methodology was considered that would allow a thorough evaluation of the discrimination capacity of intensity through the EPInfant scale, which constitutes a minimum cognitive requirement to validate PE as a parameter to dose exercise intensity in children[8]. For this reason, the sample size estimate (made *ex-ante*) was based on the average HR difference between perceptual levels 3, 6 and 9. However, there is still no scientific consensus regarding the most appropriate method for analyzing the PE clinimetric properties in the estimation-production paradigm, thus it is not possible to rule out that other analysis methods give different values to those calculated in our study.

Finally, the results of this study allow us to conclude for the first time that the EPInfant scale was a valid instrument for perceptually regulating and reproducing the intensity of treadmill exercise in children between 8 and 12 years of age. The small sample size considered allows applying these results only to the sample of studied children. However, new studies will be needed in the future to confirm and expand these findings.

## Ethical Responsibilities

**Human Beings and animals protection:** Disclosure the authors state that the procedures were followed according to the Declaration of Helsinki and the World Medical Association regarding human experimentation developed for the medical community.

**Data confidentiality:** The authors state that they have followed the protocols of their Center and Local regulations on the publication of patient data.

**Rights to privacy and informed consent:** The authors have obtained the informed consent of the patients and/or subjects referred to in the article. This document is in the possession of the correspondence author.

## Financial Disclosure

Faculty of health, School of Kinesiology, Santo Tomas University, Concepcion, Chile

## Conflicts of Interest

Authors declare no conflict of interest regarding the present study.

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