



Sport and Health Sciences, College of Life and Environmental Sciences,  
University of Exeter

**Perceived Exertion Relationships and Prediction of Peak Oxygen Uptake in Able-bodied and Paraplegic Individuals**

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*Harran Al-Rahamneh*

## Abstract

Rating of Perceived Exertion (RPE) relates to how 'hard' or 'easy' an exercise feels. The Borg 6-20 RPE scale is the most widely used scale to estimate the overall, peripheral and central perception of effort. To date, there are a limited number of studies on the use and efficacy of perceived exertion in persons with spinal cord injury and/or disease. The findings from these studies are also equivocal. Therefore, the aims of this thesis were to assess: i) the relationship between the RPE and physical and physiological markers of exercise intensity during arm cranking exercise in able-bodied and individuals with spinal cord disease, ii) the efficacy of sub-maximal RPE values to predict peak oxygen uptake during arm cranking exercise in able-bodied and paraplegic individuals using different exercise protocols, iii) the scalar property of the RPE during arm cranking exercise in able-bodied and paraplegic individuals. To achieve these goals, the thesis has been broken down to a series of seven studies. In each of these studies, except study 6, a group of able-bodied and a group of paraplegic participants were recruited to assess these hypotheses. Paraplegic individuals had spinal cord injury with neurological levels at or below the sixth thoracic vertebra (T6) or flaccid paralysis as a result of poliomyelitis infection. These individuals were physically active and participated in sports like wheelchair basketball, weightlifting, wheelchair racing and table tennis at both professional and recreational levels. Able-bodied participants were healthy and free from pre-existing injuries and physically active but not arm-trained.

There were strong relationships between the RPE and each of the physiological and physical indices of exercise intensity during arm cranking exercise regardless of group or gender. Peak oxygen uptake can be predicted with reasonable accuracy from sub-maximal oxygen uptake values elicited during a sub-maximal perceptually-guided, graded exercise test for paraplegic individuals but not for able-bodied participants. It has also been shown that peak oxygen uptake can be predicted from power output using the equation prescribed by the American College of Sports Medicine (ACSM, 2006). Furthermore, for able-bodied participants using *estimation* procedures, a

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*passive* process in which an individual is asked to rate how 'hard' or 'easy' an exercise feels, the ramp exercise test provided more accurate prediction of peak oxygen uptake compared to the graded exercise test. For paraplegic persons using *estimation* procedures, the graded exercise test provided more accurate prediction of peak oxygen uptake compared to the ramp exercise test. Finally, the scalar property of the RPE (i.e., similar proportions of time at a given RPE) was evident during arm cranking exercise regardless of group.

In conclusion, the prediction of peak oxygen uptake from sub-maximal exercise tests would provide a safer environment of exercise testing. In addition, using a sub-maximal protocol would make peak oxygen uptake more available for sedentary and clinical population compared to the graded exercise test to volitional exhaustion. Prediction of peak oxygen uptake from power output using the ACSM equation would make the estimation of peak oxygen uptake more available for large groups of people. Similar proportions of time were observed at a given RPE regardless of group or exercise intensity. The early RPE responses will give an indicator for how long a participant is going to exercise. This has important implications for rehabilitation settings. Based on the RPE responses the tester or the observer can increase or decrease the work rate to enable the participant to exercise for the desired duration.

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### List of abbreviations

ACSM - American College of Sports Medicine

BACR - British Association of Cardiac Rehabilitation

BASES- British Association of Sport and Exercise Sciences

$\dot{V}O_2$  - Volume of Oxygen Uptake

$\dot{V}O_{2max}$  - Volume of Maximal of Oxygen Uptake

$\dot{V}O_{2peak}$  - Volume of Peak Oxygen Uptake

$\dot{V}CO_2$  - Carbon Dioxide

RER - Respiratory Exchange Ratio

$\dot{V}_E$  - Volume of expired air per minute (Ventilation)

$\dot{V}_{Emax}$  - Maximal Expired Air per Minute (Ventilation)

HR - Heart Rate

HRmax - Maximal Heart Rate

$\dot{V}_E/\dot{V}O_2$  - Ventilatory Equivalent for Oxygen

$\dot{V}_E/\dot{V}CO_2$  - Ventilatory Equivalent for Carbon Dioxide

RPE - Rating of Perceived Exertion

RPE<sub>o</sub> - Overall Rating of Perceived Exertion

RPE<sub>p</sub> - Peripheral Rating of Perceived Exertion

PO - Power Output

PO<sub>max</sub> - Maximal Power Output

PO<sub>peak</sub> - Peak Power Output

W - watt

rpm - Revolutions per Minute

SCI - Spinal Cord Injury

SCD - Spinal Cord Disease

ANOVA - Analysis of Variance

ANCOVA - Analysis of Covariance

LoA - Limits of Agreement

List of abbreviations

ICC - Intraclass Correlation Coefficients

SD - Standard Deviation

GXT - Graded Exercise Test

GET - Gas Exchange Threshold

HRR - Heart Rate Reserve

$\dot{V}O_2R$  - Oxygen Uptake Reserve

CNS - Central Nervous System

PNS - Peripheral Nervous System

SNS - Somatic Nervous System

ANS - Autonomic Nervous System

Polio - Poliomyelitis

s - second

min - minute

T - Thoracic vertebra

L - Lumbar vertebra

C - Cervical

S - Sacral

SPSS - Statistical Package for Social Sciences