

Physiological and Mechanical Exercise Intensity Determination Based on Perceived Exertion

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Abstract

Self-regulating and monitoring exercise intensity is an important element of fitness improvement, health and exercise participation. Several perceived exertion scales have been developed and used internationally such as the OMNI Scale. However, this scale has not been used in production trials in the Arabic language.

Objective: The purpose of this study was to introduce a creative method to prescribe exercise intensity in a fitness program and for the first time in the Arabic language.

Method and Materials: Physiological and mechanical exercise intensity responses were measured for selected perceptual intensities using the Arabic translated format of the OMNI scale. Ten young adult subjects (21.8 yrs) performed three separate and randomly selected cycle ergometer production trials at 3, 6, and 9 intensities on the 10 point OMNI scale. The exercise duration of each exercise trial was four minutes during which the subject had two minutes to select the intensity based on the Ratings of Perceived Exertion (RPE) only. During the last minute of each trial, physiological and mechanical responses were measured for the three intensities.

Results: The responses for the 3, 6, and 9 OMNI RPEs were oxygen consumption (VO₂, L/min): 1.98, 2.94, and 4.99; Heart Rate (HR, beat/min): 97, 120, and 164; and Work Load (Watt): 52.9, 89.8, and 223.10, respectively. Regression and correlation analysis showed that the RPEs were distributed as a positive linear function of VO₂, HR, and Watt ($P < 0.05$). ANOVA with repeated measurements showed a significant difference among the different intensity responses for VO₂, HR, and Watt.

Conclusions: The results indicated the ability of exercise participants to select different exercise intensities during a fitness session using the OMNI RPEs. The scale may be used to self-regulate exercise intensities accurately and practically by the exercise participants at different intensities.

Keywords: Cardiorespiratory fitness; aerobic exercise prescription; rating of perceived exertion; OMNI scale.

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Introduction

Epidemiological studies have indicated that a low level of fitness and inactivity are linked to coronary heart diseases.¹ The increased number

of fitness facilities in Arabic speaking countries allows for a better participation in fitness sessions to improve public health and the level of physical activity.

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More exercise participation is observed among the young population in schools and universities to improve body image and health in general. The physical exertion subjective perception is the result of the feeling of effort, strain, discomfort and fatigue that a person experiences during exercise.² The use of the Ratings of Perceived Exertion (RPE) has been in practice for several kinds of indoor exercise equipment all over the world. This is noticed by the presence of the RPE scales in most fitness facilities worldwide. However, such scales are not often present in Arabic speaking countries because of the lack of understanding and validation of these scales. The use of the RPE is a recommended and accepted method in exercise testing and programming by the American College of Sport Medicine.³ These scales offer a simple, practical, accurate, and inexpensive tool for monitoring and regulating exercise intensity.

Borg of Sweden was the first to find the relation between the actual physical effort and the subjective sensation of effort (Perceived Exertion). He was the first also to develop an internationally recognized practical tool to measure perceptual effort.⁴ Several exercise scientists developed and validated similar scales for the measurement of perceived effort or exertion. These scales allow the users to choose a number (rating of perceived exertion) to describe their effort during exercise. The subjective perception of physical exertion is the result of the feeling of effort, strain, discomfort and fatigue that a person experiences during exercise.² During exercise participation, the decision about the intensity and the duration of exercise can be based upon the relation between physiological and perceptual responses.

In recent years, the OMNI scale for children⁵ has gained an international recognition in the fitness, clinical and educative settings. In addition, this scale was translated and validated in different languages, backgrounds and cultures including African American, Caucasian American, French, Irish, Chinese, Malay, Indian and Arabic.⁵⁻⁹ The Borg scale was developed prior to the OMNI scale and was the first to appear in a scientific

publication.¹⁰ These scales and more recently developed scales were prepared originally in the English language. Some exercise practitioners used these scales immediately after literary translating them into different languages without going through the validation stage of the translated version of the scale.¹¹ Previous studies showed that the RPE can be used passively to estimate the work load during testing (estimation trials) and actively to actually produce an exercise intensity to regulate exercise programs (active production trials).¹² Both estimation and production have been used in children,^{5,6,8,13,14} adults,¹⁵⁻¹⁶ healthy individuals, and some clinical individuals.¹³

To date, no study has examined the use of RPEs in the Arabic language in production trials. Therefore, it is important to examine the use of the RPE in the Arabic language and to determine if it is a valid tool to regulate exercise intensity. The simplicity and practicality of this tool allows it to replace tradition tools such heart rate monitoring and/or oxygen consumption. Language and cultural differences may impose a limitation in using perceived exertion directly translated without validation studies prior to their application.¹¹ Previous studies have used different methods to validate perceived exertion scales using mainly treadmills and cycle ergometers. These studies correlate exercise intensities with the RPE during progressive or randomized bouts of exercise using mainly the estimation trials to validate the scales.¹⁴ The use of the RPE effort estimation is applicable during exercise assessment. However, during exercise programming and exercise prescription, the RPE effort production is more applicable. Moreover, the RPE effort estimation during a maximal graded exercise test may be different than the RPE during effort production.¹⁷ This indicates the importance of scale validation in the effort production mode. Most previous studies recommended the use of the RPE as a tool of prescribing exercise intensity separately or with heart rate.¹⁸ Another previous study also emphasized the application of the production mode RPE to regulate intensity.¹²

However, the use of the RPE to regulate exercise intensity has not been studied in the Arabic language and Arabic culture. Moreover, the production mode of RPE has not been used in practical terms in Arabic speaking countries because of the lack of knowledge in exercise perception. Therefore, this study is a pioneer study in the use of the RPE production mode in the Arabic language. The purpose of this study was to assess the validity of the Arabic version of the OMNI scale (figure 1) for Arabic speaking participants by asking them to produce preselected levels of exercise intensity during cycling ergometer exercise.

Dabayebbeh (2011) (Translated and validated with permission ¹⁹)

Method

A pilot study was performed in the exercise physiology laboratory to determine the practicality of the procedures and measurements. Familiarization, RPE instructions, RPE anchoring and some practical sessions were held in this laboratory prior to the application of the study and data collection.

The study group consisted of ten exercise science students from the Faculty of Sport Science. Table (1) indicates the subjects' descriptive information.

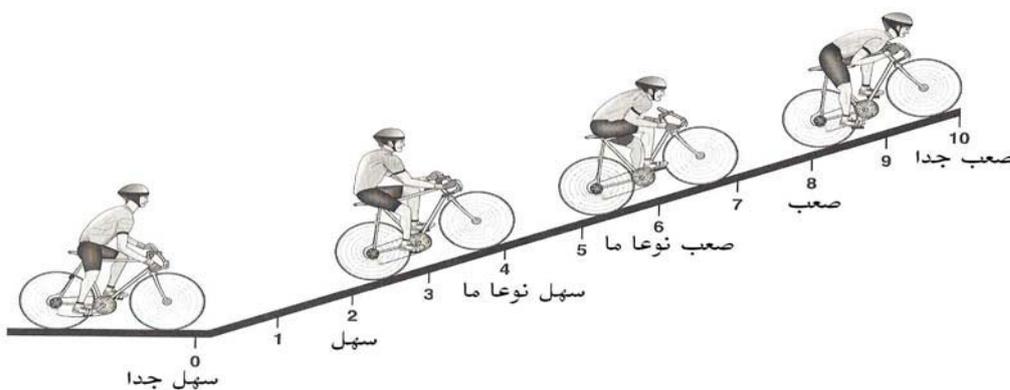


Figure (1): Validated Arabic version of the adult OMNI scale of perceived exertion for cycle ergometer exercise.

Table (1): characteristics of the sample.

	Minimum	Maximum	Mean	Std. Deviation
Weight (KG)	56.00	88.50	72.65	10.41
Height (CM)	170.00	190.00	178	6.17
Age (Yr)	19.00	25.00	21.80	1.54
Fat (%)	5.70	18.50	9.20	3.99
BMI	17.00	26.40	22.73	2.52
Waist/Hips	.78	.84	.81	.022

Subjects of the study volunteered to participate in this experiment. A consent form was signed by each one of the subjects. Prior to participation, subjects completed a current health questionnaire. All subjects were asymptomatic of illness or disease and free of acute or chronic injuries. Benefits and/or risks of participation in this experiment were explained to the subject.

Body mass (kg) and height (cm) were measured using a medical scale and attached stadiometer. Body fat percentage was estimated through the skin fold method. A waist to hip measurement (cm) was performed using a standardized method.

Production Experimental Trial: Heart Rate, Oxygen Consumption and Power output Monitoring

This experiment used perceptual production trials performed during a single session. The duration of the exercise trials were 12 minutes. All subjects were exercise science students and participated regularly in physical activity. All exercise trials were performed in the exercise physiology laboratory at the Faculty of Physical Education, University of Jordan using electrical braked bikes. Exercise trials consisted of 4-minute stages with a total of three stages.

The preselected exercise intensities were applied randomly (i.e. random order: OMNI 1 (extremely easy- easy), OMNI 5 (somewhat easy- somewhat hard), and OMNI 9 (hard- extremely hard). A pedaling rate of 60-70 revolutions per minute (RPM) in all stages was used. The RPM were signaled electronically by the computerized exercise testing bike and were monitored throughout all the experimental trials. The RPMs were visible to the subject on the screen and it was explained that the desirable pedal cadence of 60-70 was to be maintained. This was to reduce the possible effects of low pedaling cadence and therefore higher resistance per pedal revolution. All other indicators were masked from the participant throughout the trial. The Arabic version of the OMNI scale was in full view of the subject during the entire duration of the exercise test.

Heart rate monitoring (beat per minute) was performed continuously during the length of the exercise trial and was recorded during the last 10 seconds of every minute using a wireless chest strap telemetry system (polar monitoring system, Polar Electro, Kempele, Finland). Each subject's instructions included the definition of perceived exertion.^{8,19}

Using both the definition and the instruction, an anchoring system was established for each subject by explaining the lowest intensity (zero, lower anchor) and the highest intensity (ten, higher anchor)¹⁹ during the familiarization and

the testing trials. During all the length of the exercise trial, the OMNI scale was in full view of the subject. The work load was adjustable by increments of 10 – 450 W. Expired air was measured continuously using a “breath-by-breath” system. The system was calibrated using a 3 liter syringe for volume across a wide range of flow rates and against known gases for O₂ and CO₂ analyzers. The exercise intensity at each bout of exercise was adjusted by the participants to bring the intensity high or low to the appropriate level to match the preselected RPE. The subject had two minutes to self-select the appropriate exercise intensity based upon the feeling of exertion (using the RPE) scale. Once the subject selected the appropriate intensity corresponding to the chosen RPE, the mechanical intensity (i.e. work output) was not changed for two minutes to establish a steady state measurement. Each exercise bout was followed by at least a 15-minute resting period prior to starting the next level of intensity. Similar methods were validated, described and used by numerous investigations using the English language RPE scales^{17,20,21} and the same scale in the French language.¹⁵

Data Analysis

The physiological variables (i.e. heart rate HR, oxygen consumption VO₂) and the power output variables (watt) were calculated as means and standard deviations. A linear regression analysis with repeated measures over exercise intensity (RPE) was used to determine concurrent validity. The final minute HR, VO₂, and watt were regressed against the OMNI RPEs. Regression coefficients were calculated for each of the groups.

One way ANOVA with repeated measures was used on the Markers of Exercise Intensity (MEI: HR, VO₂ and PO) to examine the main effect of the RPEs preselected intensities. The analysis examined the difference in each of the MEI between the different levels RPEs.

Results

The subjects showed a very good understanding of the scale and the procedures for effort production. The analysis of the physiological and physical responses during exercise trials at different intensities using perceived exertion descriptive data (mean and standard deviation) is presented in table (2). The linear regression analysis of Heart Rate (HR), Oxygen Consumption (VO2) and Power Output (watt) expressed as a function of RPE (OMNI) during cycling exercise and their correlation were significant ($P < 0.01$) (table 3). Physiological and physical responses at each level of exercise intensity of the OMNI-Cycle RPEs are presented in figures 2, 3 and 4. All the physiological variables and PO were significantly different for the three RPE levels (i.e. 1, 5, 9) ($P < 0.01$).

Table (2): Physiological and physical responses during exercise trials at different intensities using ratings of perceived exertion to determine the level of intensity.

Variables	Mean	Std. Deviation
RPE 1 Light Intensity: HR (beat/min)	97	11.74
RPE 5 Moderate Intensity: HR (beat/min)	120	17.33
RPE 9 High Intensity: HR (beat/min)	164	11.91
RPE 1 Light Intensity: VO2 (L/min)	1.98	.42
RPE 5 Moderate Intensity: VO2 (L/min)	2.94	.86
RPE 9 High Intensity VO2 (L/min)	4.99	.89
RPE 1 Light Intensity: Power Output (Watt)	52.90	22.39
RPE 5 Moderate Intensity: Power Output (Watt)	98.80	41.12
RPE 9 High Intensity: Power Output (Watt)	223.10	59.33

Table (3): Linear regression analysis of Heart Rate, Oxygen Consumption (VO2) and Power Output (watt) expressed as a function of RPE (OMNI) during cycling exercise. The significance level was set at $P < 0.01$ for both analyses.

RPE Predictor	Slope	Intercept	r*	r ²	SEE
Heart Rate (beat/min)	8.47	85.19	.892	.796	14.50
Oxygen Consumption (L/min)	.376	1.422	.848	.720	.79
Power Output (Watt)	21.27	18.55	.837	.701	46.92

RPE: ratings of perceived exertion; SEE: Standard error of estimate. * $P < 0.01$

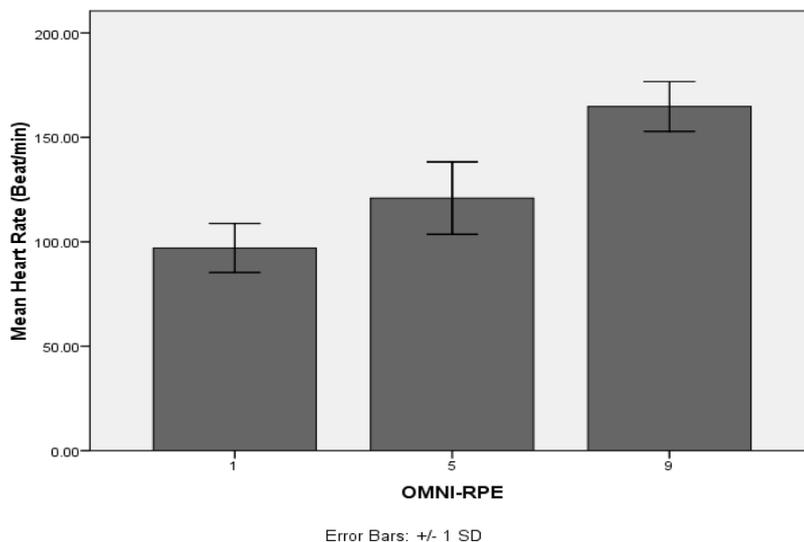


Figure (2): Heart rate responses during cycle ergometer exercise using OMNI-Cycle ratings of perceived exertion (RPEs) to determine exercise intensities.

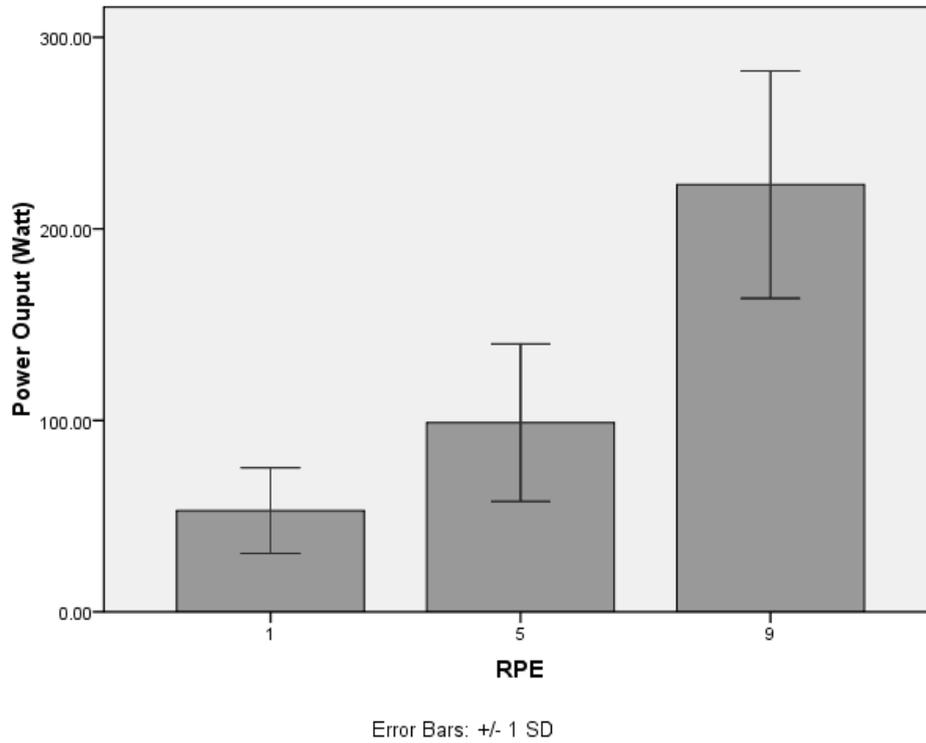


Figure (3): Power output selections during cycle ergometer exercise using OMNI-Cycle ratings of perceived exertion (RPEs) to determine exercise intensities.

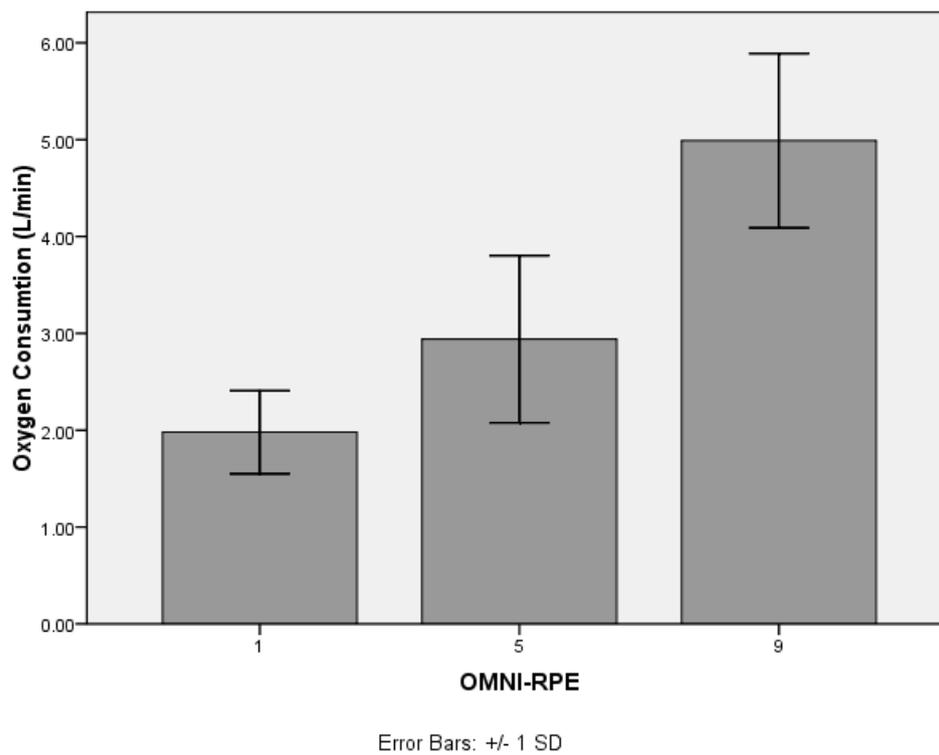


Figure (4): Oxygen consumption responses during cycle ergometer exercise using OMNI-Cycle ratings of perceived exertion (RPEs) to determine exercise intensities.

Discussion

All the subjects participating in the study were easily able to produce the preselected exercise intensity levels using OMNI scale while performing cycle ergometry. They were able to use RPE to differentiate between intensity levels. Similar results have been reported for healthy and clinical subjects using different modes of exercise indifferent to languages and cultures. The result of this study demonstrated the validity of the translated adult OMNI scale of perceived exertion for cycle ergometer exercise. The concurrent validation of the newly translated pictorial scale in the present study was evident for young adult males. The results demonstrated that as the OMNI scale RPEs increased throughout the exercise test, the markers of exercise intensity were increased in a positive and linear manner (HR, VO₂, and PO responses).

The pioneer work in the area of perceived exertion was recognized by Borg.¹⁰ He developed the first scale for the measurement of perceived exertion during physical effort in 1962.⁴ Since that date, physiological parameters to validate perceptual scale have been extensively used.^{7,8,19,22-25} This study is the first use of production trials to validate the adult RPE scale in the Arabic language and in the Arabic culture. The use of a pictorial and verbal scale is new even in the English language. The OMNI RPE scales are considered the first scale to use pictures, numbers and verbal expressions to indicate the perceived exercise intensity.²⁵

The results of this study indicated that the translated RPEs for the overall body were distributed as a positive and linear function of the physiological criterion indicated by HR. Using the production trials in this study, the results are similar between the results of the first Arabic language estimation trials⁸ and the results of the original investigation of the adult OMNI scale for cycle ergometer.²¹ Similar perceived exertion scales were validated using physiological parameters in the estimation mode.^{2,4,6,8,14,22}

In this investigation, the heart rate, VO₂ and PO

were used as physiological markers of exercise intensity. The linear regression results of the present investigation are consistent with previous research using the OMNI scale format in different cultures, different languages, adults, children, males, females and different validation methods.^{5,6,7,8,21,27} The results of the production trials of the Arabic OMNI scale in the present investigation are consistent with the results of the estimation and production trials in the English version of the original OMNI scale for cycle ergometer for adults²¹ as it was applied in the American culture. Similar results were noticed in male and female children using the OMNI-Cycle scale in both the original version⁵ and the Arabic translated version of the children OMNI-Cycle scale.⁸

The effort production in the present study employed a sub-maximal work load to validate the newly translated version of the OMNI scale. However, it is believed that the exercise intensity in the present study was high enough to indicate a validation for intensity close to the maximal (RPE 9 out of the 10 maximal points in the scale). It may be accepted to indicate that the linearity of physiological responses may be throughout the maximal effort production. This possibility was also suggested previously for the Arabic version for children and adults^{8,9} and for the OMNI scale in different languages and cultures (Malay, Chinese and Indian) by Balasekaran.⁷ However, in the estimation trials, Eston et al.¹⁴ suggested that the child's perception of exertion may increase curvilinearly with equal increments in the work rate. This may indicate higher perceptual effects for small power output increases at high intensity levels. Further investigation may be needed to examine the possibility of a curvilinear increase in the perception of exertion in an adult.

Conclusion

The effort production findings of the present study confirm the validity of the newly translated OMNI Scale of perceived exertion for cycle ergometer (Arabic language scale). In addition, the actual validation of the scale confirmed the

previous validation of the OMNI perceived exertion pictorial system in different languages and different cultures. The practical application of the Arabic OMNI scale in effort production mode confirms the application ability of the scale in different cultures and languages of the original scale. This indicates the capacity of the original scale to be used in a much broader manner. The present production validation of the Arabic version of the scale allows the use of this version in research, during exercise evaluation and most importantly as modality to prescribe and monitor aerobic exercise intensity. Future studies should explore production validation and application of the Arabic OMNI scale in healthy, clinical and rehabilitative exercise settings. Future research may investigate the use of different exercise modes (i.e. treadmill) and explore smaller intensity increments to test for the sensitivity of the scale.

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تحديد شدة التمرين الفسيولوجية والميكانيكية بالاعتماد على معيار الشعور الذاتي الخاص بشدة الجهد المدرك

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الملخص

الهدف: هو التحقق من المصادقية والقدرة التطبيقية للمعيار الخاص بتحديد شدة التمرين الهوائي من خلال استخدام الشعور بمستوى الجهد (بالاعتماد على المعيار العالمي OMNI الخاص بذلك) (Production Paradigm) وباللغة العربية.

الإجراءات: تكونت عينة الدراسة من 10 من الذكور (21.8) حيث تضمنت إجراءات الدراسة الطلب من المشاركين تحديد شدة التمرين الميكانيكية المناسبة بشكل ذاتي وبالاعتماد على المعيار العالمي OMNI وعلى مستويات مختلفة من الشدة المنخفضة (3)، المتوسطة (6)، والعالية (9) على المعيار. تم اختيار شدة التمرين في كل محاولة بشكل عشوائي ومنفرد لكل مشترك حيث كانت مدة التمرين 4 دقائق لكل محاولة. بعد كل محاولة تم قياس مؤشرات الشدة الفسيولوجية (النبض، واستهلاك O₂) والشدة الميكانيكية المنتجة (WATT).

النتائج: تحليل الانحدار الخطي والارتباط بين الشعور بشده التمرين الذاتية وشده التمرينات الفسيولوجية والميكانيكية (مؤشرات: النبض، WATT واستهلاك O₂) كانت دالة إحصائيا ولجميع المؤشرات ($P < 05$). تحليل ANOVA للقياسات المتكررة للمؤشرات الفسيولوجية والميكانيكية الخاصة بشدة التمرين إشارة إلى اختلافات بين الشدة المنخفضة والشدة المتوسطة والشدة العالية ($P < 05$).

الاستنتاجات: تشير النتائج إلى مصادقية هذا المعيار وقدرته على تحديد شدة التمارين الرياضية والهوائية بشكل ذاتي من قبل المشارك، وبشكل دقيق علميا وسهل عمليا سواء في اختبارات اللياقة البدنية أو في كتابة البرامج الرياضية بشكل عام ومراقبة شدة التمرين بشكل خاص.

الكلمات الدالة: فسيولوجيا التدريب الرياضي، القياسات الفسيولوجية، معايير الشعور بشدة التمرين، التدريبات الهوائية، اللياقة البدنية.