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The validity of the Borg Scale for perceived exertion in determining levels of aerobic exercise intensity through physiological and performance measurements during and after Ramadan

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Abstract:

The self-regulation of exercise intensity is essential in promoting consistent exercise engagement using validated tools such as the Borg scale. Nonetheless, the validation of the Borg scale within the context of Arabic-speaking populations during the month of Ramadan had not been explored before. This study aimed to determine the usability of the Borg scale in measuring perceived exercise exertion during and after fasting in Ramadan, to generate various levels of aerobic exercise intensity, and its relationship with physiological response (heart rate) and performance capacity (running speed). Eighteen healthy males with a mean ± SD age of 21.84±1.37 years participated in this study. Each participant was asked to run on a treadmill for 3 trials at low, medium, and high perceived intensities, during which the physiological and performance responses were measured. All procedures were conducted during the 2nd and 4th weeks of Ramadan and the 2nd week after Ramadan. Significant differences were found in produced physiological and performance responses among all intensities at all study times. The results indicate the validity of the Borg scale and its capability to produce different levels of aerobic intensity during and after Ramadan. Furthermore, findings show that Ramadan may lead to physiological adaptations after 4 weeks from its beginning.

Key Words: Exercise Physiology, Borg Scale, Perceived Exertion, Heart Rate, Running Speed, Fasting, Aerobic Training.

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Introduction:

The perception of physical exertion intensity, commonly referred to as exercise perception, encompasses the subjective experience of exertion, fatigue, discomfort, and strain during physical activity (Noble & Robertson, 1996). This concept rests on the principle that individuals engaged in sports and physical exercise can monitor their levels of fatigue, musculoskeletal strain, and cardiovascular stress. Various scales, such as the Borg scale for Ratings of Perceived Exertion (RPE), have been employed globally to objectively assess perceived intensity across different sports and physical activities. The American College of Sports Medicine (ACSM) has endorsed the use of perceived intensity scales as credible tools for assessing and regulating exercise intensity during training, offering simplicity, practicality, accuracy, and cost-effectiveness.

Athletes and sports participants typically assess training intensity through various means, including heart rate, blood lactate levels, oxygen consumption, or resistance levels. Nevertheless, perceived exertion measurement remains the most prevalent method applicable across diverse activities, irrespective of intensity or energy system dominance. Since its inception in 1962, the Borg Scale has served as the primary reference for quantifying perceived exercise intensity globally, widely utilized for measuring physiological and performance intensity levels based on perceptual exertion (Borg, 1962).

The psychophysical intensity perceived during sports activity is influenced by various physiological changes (muscular, metabolic, neural) occurring in the body during physical exertion. This psychophysical intensity can be quantified using perceived intensity scales like the Borg scale (Robertson, 2004). The ease of assessing physical effort intensity via perceived intensity contributes significantly to maintaining training consistency and participation in physical activities, thereby enhancing athletic training outcomes.

Monitoring training intensity is a cornerstone of effective training programs, prioritizing individual variances and overall player safety. The Borg scale's reliability has been validated across diverse cultures, languages, and environmental conditions, consistently demonstrating robust psychometric properties (Balasekaran et al., 2005; Buckley et al., 2000; Byrne & Eston, 1998; Dabayebeh, 2011). However, its validity during the fasting month of Ramadan remains unexplored, despite its widespread use during this period (Boukhris et al., 2019; Chtourou et al., 2011; Fashi et al., 2021; Hsouna et al., 2020).

Further research into the impact of Ramadan fasting and intermittent fasting diet on perceived exercise intensity is warranted to understand its effect on measurement credibility and cognitive ability to assess and sustain desired exercise intensity, particularly given the upcoming WEFA European Football Championship coinciding with Ramadan. During Ramadan, Muslims observe fasting from sunrise to sunset for approximately 30 consecutive days, involving daily fasting periods of over 14 hours with unrestricted evening food and drink intake, leading to significant lifestyle adjustments in sleep, nutrition, and mental state (Chtourou et al., 2011).

Despite these challenges, Muslim athletes continue training, adapting their routines based on pre-Ramadan intensity levels. Traditionally, most Muslim athletes rely on methods like heart rate and lactate threshold to monitor exercise intensity during Ramadan. However, these methods are susceptible to factors such as dehydration, nutritional deficiencies, and sleep deprivation (Boukhris et al., 2019). Despite increasing research during Ramadan, understanding cognitive variables associated with exercise intensity remains limited, with disparate findings (Abaidia et al., 2020).

Reliable and objective tools for measuring exercise intensity can enhance understanding of Ramadan's impact on training, physiological, and psychological variables among athletes and sports participants. There is no consensus on Ramadan's effect on exercise performance, with studies showing variable results on aerobic and anaerobic capacity across different intensity levels (Abedelmalek et al., 2022; Chtourou et al., 2011). Factors such as insufficient sleep and dietary changes during Ramadan have been implicated in affecting athletic performance (Lipert et al., 2021). Insufficient training during Ramadan may contribute to performance decline (Abedelmalek et al., 2022), affecting both local and international competitions for Muslim athletes (Lipert et al., 2021).

Many coaches report that Muslim athletes fasting during Ramadan may struggle to adapt to training, potentially reducing training frequency and intensity. Studies indicate that individuals during Ramadan may experience fatigue, lethargy, mood fluctuations, and diminished ability to sustain training intensity (Borg, 1962; Buckley et al., 2000). Adaptation strategies during Ramadan, such as adjusting training frequency, intensity, duration, and timing, may result in decreased physical fitness and performance levels. Thus, using a validated tool to determine the exercise intensity may help to avoid such a decrement in performance.

Variations in adaptation behaviors, cultural factors, geographical regions, and temperature fluctuations contribute to inconsistent study findings on Ramadan fasting's impact on physical activity and athletic performance (Abedelmalek et al., 2022). Previous studies' discrepancies in athletic performance during Ramadan may stem from inadequate assessment methods (Al-Nawaiseh et al., 2021; Balasekaran et al., 2008; Byrne & Eston, 1998; Dabayebeh, 2011), lack of detailed training descriptions (Al-Nawaiseh et al., 2021; Aziz et al., 2012; Balasekaran et al., 2008; Bar-Or & Reed, 1986; Borg, 1961; Borg, 1962; Buckley et al., 2000; Byrne & Eston, 1998; Dabayebeh, 2010, 2011), and absence of non-fasting control groups for comparison (Abedelmalek et al., 2022; Balasekaran et al., 2005; Boukhris et al., 2019; Hsouna et al., 2020).

Globally, coaches typically employ traditional methods like heart rate monitoring, distance covered, or resistance levels to determine exercise intensity, focusing on external loads. However, internal stress, or perceived exertion, plays a crucial role in athletes' experiences during fasting (Balasekaran et al., 2008). Therefore, establishing a link between fasting during Ramadan and exercise performance from a self-perceived cognitive perspective is essential.

Validating tools like the Borg scale for use during Ramadan can assist coaches in adjusting training intensity levels, minimizing fasting's impact on training programs, and maintaining acquired adaptations. Understanding athletes' stress levels during Ramadan can prevent overtraining and severe fatigue, preserving performance levels throughout the fasting period (Chtourou et al., 2011; Fashi et al., 2021).

The objectives of this study were twofold: (1) to evaluate the effectiveness (validity) of the Borg scale in assessing perceived exertion during and after fasting in Ramadan across different levels of aerobic exercise intensity, and (2) to examine the influence of fasting on physiological response (heart rate) and performance capacity (running speed) measured through the Borg scale of exercise perception, at varying levels of aerobic exercise intensities.

Materials & Methods:

Design and Ethics :

The study employed a upcoming quasi-experimental design, aligning with its objectives. Prior to participation, the potential benefits and risks associated with involvement in the experiment were thoroughly explained to the participants. After comprehensive clarification of all experimental procedures, interested participants provided informed written consent. Approval for the study procedures was obtained from the Institutional Review Board of the University of Jordan (IRB No. 20244241, Date: 2024).

Study sample:

A total of 18 participants successfully completed the three sessions of the experiment. Before their involvement, all participants completed a comprehensive general health survey to ensure they were in good health, without any symptoms of illness or injuries. Their commitment to fasting throughout the month was confirmed through personal interviews conducted with each participant prior to engaging in the physical experiments. Notably, the cohort comprised Muslim individuals who had observed fasting practices throughout the month of Ramadan since a young age, typically starting at 7 or 8 years old. Measurements of body mass (in kilograms) and height (in centimeters) were obtained using a medical scale and a stadiometer, respectively, after which the body mass index (BMI) was computed.

Procedures:

The study was conducted during the month of Ramadan, with the daily fasting period spanning from 5 AM to 7 PM, resulting in an average fasting duration of 14 hours per day. Previous research on perceived exertion has utilized two distinct methods for employing perceived exertion scales. The first method, termed "production of intensity," involves participants generating a specific level of training intensity (e.g., speed) corresponding to a given number on the scale. For instance, participants may be instructed to run at level 13 on the Borg scale, representing moderate intensity, with their resulting speed subsequently measured (Dabayebeh, 2011). The second method, known as the "estimation of intensity," entails participants estimating the level of exertion using a provided scale (e.g., the Borg scale) based on the exercise intensity determined by the examiner (Robertson et al., 2000).

Participants underwent familiarization and training in the use of the Borg scale (anchoring the perceptual range as suggested by Noble and Robertson, 1996) at various intensity levels, employing both production and estimation methods prior to the onset of Ramadan, conducted on a treadmill (Life Fitness Treadmill, USA) (Dabayebeh, 2010; Robertson, 2004). However, the present study exclusively employed the first method (production on the Borg scale for perceived exertion).

The Borg scale, comprising 15 points for Rating of Perceived Exertion (RPE), ranges from 6 denoting "no exertion" to 20 representing "very hard." Guidelines for forward/backward translation were adhered to for the Borg scale to develop the final version in Arabic (Sperber, 2004).

During each session, participants engaged in treadmill running at randomly assigned Borg intensity levels (one of the three pre-determined exercise intensity levels), for a duration of two minutes (Buckley et al., 2000; Dabayebeh, 2010; Dabayebeh et al., 2012). Participants had the autonomy to adjust treadmill speed based on their perceived exertion to align with the specified Borg intensity level designated by the examiner. However, during

the third minute, participants were required to maintain a constant speed without further adjustments. At the conclusion of the third minute, treadmill speed (expressed in kilometers per hour: km/h) was documented to assess performance capacity, while heart rate (measured in beats per minute) was recorded to evaluate physiological response. Importantly, participants remained unaware of these indicators throughout the experiment.

Continuous monitoring of heart rate occurred throughout the experiment, with recordings taken during the final ten seconds of each minute utilizing a remote measuring system equipped with a chest strap (Polar Electro, Kempele, Finland). This protocol was replicated for each of the three intensity levels within every session. Adequate recovery time was allowed for subjects between trials to permit heart rate recovery (to reach within 10% of pre-exercise HR). The experiments were conducted twice during Ramadan (in the 2nd and 4th weeks) and once post-Ramadan (in the 2nd week thereafter)."

Validity and Reliability of Study Instruments:

The validity and reliability of the study instruments were ensured through the utilization of meticulously selected devices and tools within the medical domain. These instruments were chosen based on their established validity and reliability, manufactured with precision, and employed in accordance with recommended standards provided by the manufacturer. Furthermore, these devices have been extensively utilized in prior studies within the sports domain, underscoring their reliability and suitability for this investigation.

Statistical Analysis:

Statistical analyses were performed using the Statistical Package for the Social Sciences (SPSS) for all statistical procedures. The variance between performance and physiological response levels resulting from the use of the scale at perceptual intensity levels during and after Ramadan was calculated. One-way repeated-measures analysis of variance (ANOVA) was used for produced intensity levels (heart rate and speed). Two-way repeated-measures ANOVA (3x3) was used to measure the time effect (the 2nd week of Ramadan, the 4th week of Ramadan, the 2nd week after Ramadan) and the Borg scale intensity levels (Buckley et al., 2000; Dabayebeh, 2010).
Linear regression and correlation analyses were conducted between self-perceived exercise intensity and physiological and performance exercise indicators (heart rate and speed) recorded in the last minute of each test trial. The significance level was set at $P < 0.05$.

Results:

Table 1 displays the characteristics of the study sample. Participants exhibited proficient comprehension of the Borg scale for perceived exertion and adeptness in generating intensity levels corresponding to various Borg categories, with 9 indicating low intensity, 13 for moderate intensity, and 17 for high intensity levels.
Tables 2 and 3 delineate the outcomes concerning physiological responses (heart rate) and performance capacity (running speed) across the three visits, encompassing the utilization of the Borg scale for perceptual intensity both during and post-Ramadan.

Table 1. Sample characteristics (N=18)

Variables	Mean ± SD	Range
Age (years)	21.89±1.37	20.00-26.00
Weight (kg)	73.44±11.35	57.00-97.00
Height (cm)	178.89±8.48	165.00-202.00
BMI	22.54±2.71	16.40-27.20
Fat percentage	12.29±2.92	7.50-18.90
Height/weight	0.84±0.07	0.64-0.92

Table 2. Physiological response (heart rate) according to the Borg scale intensity levels and visits

Borg scale level	Low (9)	Moderate (13)	High (17)
Visits	Mean ± SD	Mean ± SD	Mean ± SD
2nd week of Ramadan	102.06±15.43	139.83±20.76	168.28±16.64
4th week of Ramadan	95.89±14.80	128.06±22.43	160.33±21.90
2nd week after Ramadan	105.56±11.18	134.67±18.30	163.67±17.25

Table 3. performance capacity (running speed) according to the Borg scale intensity levels and visits

Borg scale level	Low (9)	Moderate (13)	High (17)
Visits	Mean ± SD	Mean ± SD	Mean ± SD
2nd week of Ramadan	3.9 ±1.38	8.18±2.03	11.28±2.35
4th week of Ramadan	4.04±1.35	7.57±1.91	11.24±2.93
2nd week after Ramadan	4.47±1.55	7.66±1.72	10.94±2.02

Reliability of the Borg scale among different perceived exertion intensity Borg levels:

1. Physiological response (heart rate) variable:

Table 4 presents the outcomes of a one-way repeated measures analysis for the heart rate variable, categorized by the perceived exertion variable and the week of measurement. The obtained significance level (P-value) was found to be highly significant (<0.001) during both the 2nd and 4th weeks of Ramadan. Similarly, the significance level for the post-Ramadan measurements was also highly significant (<0.001).

A comparison of these significant level values reveals that all calculated values were significant. This indicates that the differences observed among the mean values of heart rate, serving as a physiological indicator, across the three intensity levels (17, 13, 9), corresponding to high, moderate, and low intensity, respectively, are statistically significant in each visit, whether during the fasting month of Ramadan or post-Ramadan (Figure 1). Consequently, this underscores the participants' capacity to elicit varying degrees of physiological exertion, as reflected in heart rate, through the utilization of the Borg scale.

Table 4. One-way repeated measures ANOVA for the heart rate variable among perceived exertion intensities in each measurement visit

Visits	Source	Sum of squares	df	Mean of squares	F-Value	P-Value
2nd week of Ramadan	RPE	39729.78	2	19864.89	140.98	<0.001
	Error	4790.89	34	140.91		
4th week of Ramadan	RPE	37377.81	2	18688.91	121.88	<0.001
	Error	5213.52	34	153.34		
2nd week after Ramadan	RPE	30392.15	2	15196.07	118.89	<0.001
	Error	4345.85	34	127.82		

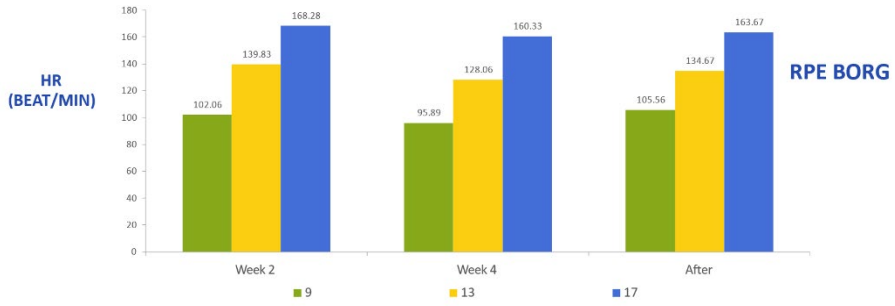

Figure (1). Heart rate increase with the increase in the Borg scale levels.

Table 5 displays the findings of a simple linear regression analysis aimed at predicting heart rate values based on perceived exertion for each measurement visit. Examination of the R2 values, which represent the proportion of variance explained by the predictive model, reveals substantial explanatory power. Specifically, the predictive model achieved an R2 value of 70.7% in the second week of Ramadan, 64.7% in the fourth week of Ramadan, and 70.2% in the second week after the end of Ramadan. These values indicate a high level of predictability, showing that the perceived exertion variable alone can explain a significant portion of the variance or difference in heart rate values. The final column of the table presents the formulated linear equations intended for predicting heart rate values based on the perceived exertion variable."

Table 5. Simple linear regression analysis to predict heart rate values through perceived exertion in each measurement visit

Visits	R	R^2 (%)	B	SE	Constant	Equation
2nd week of Ramadan	0.841	70.7	8.28	0.74	29.11	HR=8.28 PE + 29.11
4th week of Ramadan	0.804	64.7	8.06	0.83	23.37	HR=8.06 PE + 23.37
2nd week after Ramadan	0.838	70.2	7.26	0.66	40.20	HR=7.26 PE + 40.20

2. **Performance capacity (running speed) variable**:

Table (6) presents the outcomes of a one-way repeated measures ANOVA conducted on the speed variable, categorized by perceived exertion and measurement visit. Upon examining the significance level values, it becomes apparent that all reached <0.001 for the second and fourth weeks of Ramadan, as well as the second week after Ramadan. This signifies that the observed differences among the calculated mean values for the three exertion levels are statistically significant in each measurement visit, as illustrated. This underscores the efficacy of the Borg perceived exertion scale in eliciting diverse levels of performance exertion, as indicated by running speed.

Table 6. One-way repeated measure ANOVA for the speed variable based on perceived exertion in each measurement visit

Visits	Source	Sum of squares	df	Mean of squares	F-Value	P-Value
2nd week of Ramadan	RPE	484.01	2	242.00	118.93	<0.001
	Error	69.19	34	2.03		
4th week of Ramadan	RPE	465.90	2	232.95	104.64	<0.001
	Error	75.69	34	2.23		
2nd week after Ramadan	RPE	377.03	2	188.52	184.57	<0.001
	Error	34.73	34	1.02		

Table (7) presents the outcomes of simple linear regression analysis aimed at predicting speed values based on perceived exertion for each measurement visit. Evaluation of the R2 values for the predictive model reveals notable explanatory power. Specifically, the model achieved an R2 value of 70.6% for the second week and 66.1% for the fourth week of Ramadan. Regarding the measurements taken after Ramadan, it reached an R2 value of 70.2%. These values indicate a substantial ability of the perceived exertion variable, as the sole predictor, to account for the variance or difference in speed values. The final column of the table presents the formulated linear equations intended for predicting speed values based on the perceived exertion variable.

Table 7. Simple linear regression analysis to predict speed values through perceived exertion based on the Borg scale in each measurement visi

Visits	R	R^2 (%)	B	SE	Constant	Equation
2nd week of Ramadan	0.840	70.6	0.91	0.08	- 4.06	Speed= 0.91 PE - 4.06
4th week of Ramadan	0.813	66.1	0.89	0.09	- 4.07	Speed=0.89 PE - 4.07
2nd week after Ramadan	0.838	70.2	0.81	0.07	- 2.83	Speed=0.81 PE - 2.83

Reliability of the Borg scale among measurement visits at each level of perceived exertion intensity:

1. Physiological response (heart rate) variable:

Table (8) presents the outcomes of a one-way repeated measures ANOVA conducted on the heart rate variable across the measurement visits, stratified by each level of perceived exertion intensity. Upon inspection of the significance level values, it is observed that for the perceived exertion levels of 9 and 13, the values were 0.010 and 0.043, respectively. However, for the perceived exertion level of 17, the P value was not significant (0.167). This indicates statistically significant differences in the heart rate variable across the three measurement visits for perceived exertion levels of 9 and 13. Conversely, no significant differences in the heart rate variable across the three measurement visits were observed for the perceived exertion level of 17. In summary, while there are statistically significant differences in the heart rate variable for the perceived exertion levels of 9 and 13 between the measurement weeks, no such significant differences were observed at the perceived exertion level of 17**.**

Table 8. One-way repeated measure ANOVA for the heart rate variable for each level of exertion according to the measurement visits

Borg level of exertion	Source	Sum of squares	df	Mean of squares	F-Value	P-Value
9	Visit	862.33	2	431.17	5.32	0.010
	Error	2755.00	34	81.03		
13	Visit	1254.70	2	627.35	3.46	0.043
	Error	6166.63	34	181.37		
17	Visit	572.93	2	286.46	1.89	0.167
	Error	5159.74	34	151.76		

Table (9) presents the outcomes of the least significant difference test for the heart rate variable across each level of exertion relative to the measurement visit. Analysis of the differences reveals significant variances primarily observed in the second and fourth weeks for both exertion levels 9 and 13.

Specifically, for force level 9, differences were noted between the second and fourth weeks of Ramadan, favoring the second week where the average heart rate value was higher. Similarly, for exertion level 13, differences were observed between the second and fourth weeks of Ramadan, again favoring the second week with a higher average heart rate value.

Moreover, an additional difference was identified in exertion level 9 between the fourth week of Ramadan and the second week after Ramadan. Here, the significance of the difference favored the second week after Ramadan, where the average heart rate value was the highest among the measured visits.

Table 9. Results of the least significant difference test for the heart rate variable for each exertion level according to the measurement visits

Borg level of exertion	Mean of heart rate (beat/min)	Visits		
		2nd week of Ramadan	4th week of Ramadan	2nd week after Ramadan
9	102.06	2nd week of Ramadan	*	
	95.89	4th week of Ramadan		*
	105.56	2nd week after Ramadan		
13	139.83	2nd week of Ramadan	*	
	128.06	4th week of Ramadan		
	134.67	2nd week after Ramadan		

2. Performance capacity (running speed) variable:

Table (10) displays the outcomes of a one-way repeated measures ANOVA conducted on the speed variable, stratified by the level of perceived exertion and the measurement visit. Upon examination of the significance level values, it is apparent that they reached 0.263 for perceived exertion level 9, 0.373 for perceived exertion level 13, and 0.783 for perceived exertion level 17.

Comparing these values with the conventional threshold of 0.05, it is evident that the calculated values were greater, indicating that the observed differences in the calculated mean values across the three measurement visits were not statistically significant for each level of perceived exertion.

This suggests that the produced speed at each level of exertion, and across the three levels of exertion, remains unaffected significantly by reliance on the perceived exertion scale during Ramadan. Thus, it confirms the participants' ability to maintain similar levels of mechanical or performance exertion (speed) at the same perceived exertion or load both during and after Ramadan.

Table 10. Results of one-way repeated measures ANOVA for the speed variable distributed by the level of perceived exertion and the measurement visits

Borg level of exertion	Source	Sum of squares	df	Mean of squares	F-Value	P-Value
9	Week	2.57	2	1.28	1.39	0.263
	Error	31.39	34	0.92		
13	Week	3.88	2	1.94	1.02	0.373
	Error	64.88	34	1.91		
17	Week	1.24	2	0.62	0.25	0.783
	Error	85.51	34	2.51		

Discussion:

Numerous studies worldwide have explored the impact of fasting on physical performance (Al-Nawaiseh et al., 2021; Castilho et al., 2021; Stannard & Johnson, 2004; Stannard, 2011). Some of these investigations utilized perceived exertion scales as a means to gauge and determine levels of physiological or performance exertion during Ramadan fasting, albeit without validating the reliability of these scales in the Arabic language (Chtourou et al., 2011).

The primary objective of this study was twofold: firstly, to ascertain participants' proficiency in utilizing the Borg scale during sports activities to achieve predetermined levels of exercise intensity for low, moderate, and high loads during Ramadan. Secondly, to elucidate the effects of fasting on physiological and performance variables based on perceived exertion measurement tools.

The first perceived exertion scale was developed by Borg in 1962 (Borg, 1961; Borg, 1962), and since then, physiological indicators have been employed to corroborate the practical application of perceptual concepts extensively (Dabayebeh, 2013; Nakkanung et al., 2012; Robertson et al., 2000). This study represents the first attempt to validate the Borg Ratings of Perceived Exertion (RPE) scale for adults in the Arabic language and culture during Ramadan fasting, using exertional efforts as a means of verification. To the best of our knowledge, no prior investigations have undertaken the validation of these measures during the fasting period of Ramadan.

The findings of this study suggest that participants were proficient at achieving the prescribed exercise intensity levels using the Borg scale during both Ramadan fasting and after Ramadan. Utilizing the Borg perceived exertion scale, they demonstrated the ability to accurately discern and attain intensity levels as instructed by the examiner, without access to or knowledge of physiological or performance variables typically monitored via electronic sports devices, such as heart rate or treadmill speed. The escalation in heart rate and running speed corresponded with increased perceived exertion levels, consistent across both fasting and post-fasting conditions (Balasekaran et al., 2008; Dabayebeh, 2010; Robertson et al., 2000). Similarly, correlations between physiological and performance variables on one hand and perceptual variables on the other were coherent. These results are in line with prior studies affirming the reliability of the scale across diverse populations, exercise patterns, languages, and cultures, albeit not specifically during Ramadan fasting (Castilho et al., 2021).

Furthermore, this study confirms the Borg perceived exertion method's efficacy in eliciting desired levels of aerobic exertion during Ramadan, irrespective of fasting or post-fasting states, in a largely uniform manner. This indicates that participants' perceptual ability regarding exercise intensity remained largely unaffected by Ramadan fasting across low, moderate, and high exertion levels. This finding resonates with previous research conducted under various environmental conditions (Maw et al., 1993; Scherr et al., 2013).

Moreover, aside from a decrease in heart rate observed during the fourth week of Ramadan, no disparities were noted in physiological and performance exertion levels across perceived exertion categories between fasting and non-fasting conditions. The observed decrease in heart rate suggests a potential physiological adaptation after prolonged fasting, possibly attributable to improved hydration status and enhanced stroke volume over time during fasting. This finding aligns with studies highlighting physiological adaptations to Ramadan fasting, such as increased fat utilization over carbohydrates during aerobic exertion (Stannard & Johnson, 2004; Stannard, 2011). This finding further suggests the need for specific Ramadan coping strategies to avoid possible dehydration (Djemai et al., 2020).

These results underscore the practical utility of the Borg scale in measuring external or performance exertion (e.g., treadmill speed) through internal (perceived) exertion standards. The scale's credibility and accuracy appear independent of fasting states, and fasting did not substantially influence participants' ability to achieve desired intensity levels. The validation of the scale during Ramadan fasting in this study suggests that a specific perceived exertion scale for use during Ramadan may be unnecessary, consistent with prior findings (Maw et al., 1993).

Additionally, the study indicates a positive correlation between perceived exertion levels on the Borg scale and physiological/performance indicators, such as heart rate and running speed, during exercise tests. This

finding supports the efficacy of using perceptual exertion in designing training programs (Scherr et al., 2013) and underscores the Borg perceived exertion method's cost-effectiveness and simplicity in determining exercise intensity with high credibility and accuracy.

However, it is imperative to further validate the use of the Borg scale during Ramadan fasting through additional studies. Cultural, geographical, environmental, and dietary factors prevalent in different Islamic regions during Ramadan may influence or alter the study results, as evidenced by previous research highlighting the role of these variables. Methodologically, employing more than three exertion levels may yield more precise and credible results than those obtained in this study. Consequently, the generalizability of the current findings remains limited, underscoring the need for similar investigations across diverse regions, conditions, and sports, encompassing both male and female participants and spanning more than three exertion levels.

Furthermore, exploring potential physiological adaptations, such as hydration levels and stroke volume, and understanding their correlation with perceived exertion due to fasting towards the end of Ramadan, warrants further investigation.

Conclusions:

In this study, participant's demonstrated proficiency in utilizing the Borg scale for perceived exertion to effectively achieve prescribed physiological and performance exertion levels across three categories: low, moderate, and high during and after Ramadan. Physiological and performance variables consistently mirrored perceptual variables, with indicators of exercise intensity escalating in tandem with perceived exertion. Participants exhibited the capacity to self-regulate exercise intensity internally, adjusting exertion levels as required based on the Borg scale. These findings support previous research affirming the reliability of the Borg scale across diverse conditions, prompting the recommendation for further investigations across varied circumstances and demographic groups, including both males and females.

Recommendations:

The Borg scale for perceived exertion has been recommended for further research. It should be incorporated into studies to assess gender-specific differences and age diversity. The scale should also be explored for its applicability in various environmental conditions, physical activities, and seasonal effects. Longitudinal studies should be conducted to understand how perception of exertion and self-regulation change over time. Technological integration, such as wearable technology and mobile applications, could enhance user engagement and accuracy. Psychological and cognitive factors, such as mental fatigue and motivation, should also be explored. Furthermore, the scale can be beneficial in clinical and rehabilitation settings, such as those involving cardiovascular disease or respiratory conditions.

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مدى صلاحية مقياس بورغ (Borg) للشده المدركه لتحديد مستويات شدة التمرين الهوائية من خلال القياسات الفسيولوجية والأدائيه في شهر رمضان

الملخص :

ان تنظيم الشدة الادراكية للتمارين البدنية ضروري لتعزيز الالتزام المستمر بممارسة الرياضة باستخدام أدوات معتمدة مثل مقياس بورغ. ومع ذلك، فإن التحقق من صحة استخدام مقياس بورغ في سياق الناطقين باللغة العربية خلال شهر رمضان لم تتم دراسته من قبل. وعليه، هدفت هذه الدراسة إلى تحديد مناسبة (صلاحية) استخدام مقياس بورغ في قياس الشدة الادراكية أثناء وبعد الصيام في شهر رمضان لتوليد مستويات مختلفة من شدة التمارين الهوائية وعلاقتها بالاستجابة الفسيولوجية (معدل ضربات القلب) وقدرة الأداء (سرعة الجري).

شارك في هذه الدراسة ثمانية عشر شابًا يتمتعون بصحة جيدة بمتوسط عمر يبلغ 21.84 ± 1.37 سنة. تضمنت اجراءات الدراسة الطلب من كل مشارك الجري على جهاز المشي في ثلاث تجارب وانتاج شدة منخفضة (9) ومتوسطة (13) وعالية (17) بالاعتماد على الادراك فقط من خلال النظرالى المقياس العالمي بورغ (6–20)، حيث تم قياس الاستجابات الفسيولوجية والأداء على كل مستوى من الشدة. تم إجراء جميع الإجراءات السابقة في الأسبوعين الثاني والرابع من شهر رمضان وبعد اسبوعين من انتهاء شهر رمضان.

تضمنت النتئج ايجاد فروقات كبيرة في الاستجابات الفسيولوجية ومؤشرات الأداء الناتجة عن جميع مستويات الشدة في جميع أوقات الدراسة. وتشير النتائج إلى صحة مقياس بورغ وقدرته على إنتاج مستويات مختلفة من الشدة الهوائية أثناء وبعد الصيام في شهر رمضان. وعلاوة على ذلك، تُظهر النتائج أن رمضان قد يؤدي إلى تكيفات فسيولوجية بعد 4 أسابيع من بدايته.

الكلمات المفتاحية: فسيولجيا التدريب، مقياس بورغ، الجهد المبذول، معدل ضربات القلب، سرعة الركض، الصيام، التدريب الهوائي.