Biology and Medicine

Monda et al., Biol Med (Aligarh) 2015, 1:2
DOI: 10.4172/0974-8369.1000s3008

Review Article Open Access

Relationship between RPE and Blood Lactate after Fatiguing Handgrip Exercise in Taekwondo and Sedentary Subjects

Moscatelli F[1,2], Messina G[1,3], Valenzano A[1], Petito A[1], Triggiani AI[1], Ciliberti MAP[1], Monda V[3], Messina A[3], Tafuri D[4], Capranica L[2], Cibelli G[1] and Monda M[3*]

[1]*Department of Clinical and Experimental Medicine, University of Foggia, Foggia, Italy*

[2]*Department of Motor, Human and Health Science, University of Rome,"Foro Italico", Rome, Italy*

[3]*Department of Experimental Medicine, Section of Human Physiology and UOC Clinical Dietetic and Sport Medicine, Second University of Naples*

[4]*Dept of Motor Sciences and Wellness, University of Naples "Parthenope", Naples, Italy*

[*]**Corresponding author:** Marcellino Monda, Department of Experimental Medicine, Section of Human Physiology and Clinical Dietetic Service, Second University of Naples, Via Costantinopoli 16, 80138 Naples, Italy, Tel. +39 +81 566 5804; Fax +39 +81 5665844; E-mail: marcellino.monda@unina2.it

Received date: May 25, 2015; **Accepted date:** July 30, 2015; **Published date:** August 6, 2015

Abstract

Purpose: To get information on the effort during vigorous exercise there are different ways and, the most popular, is the scale to measure subjective exertion or the rating of perceived exertion (RPE), such as the Borg scale. This scale is an effective methods to quantify and monitor the intensity of the exercise The aims of this study were to investigate the association between RPE, blood lactate concentration and maximal voluntary handgrip (MVG) force, after fatiguing exercise in athletes and non-athletes.

Method: Twelve right-handed male taekwondo athletes (age: 27 ± 5 years) and 12 matched controls (age: 26 ± 5 years) were recruited. Peak force was measured and, after a subsequent rest, subjects were asked to reproduce 30% of their MVG for 4 s, then relax for 2 s, and then repeat this sequence for 10 minutes. Blood lactate was measured at rest (pre), at the end (0 min) as well as 3 and 10 min of the recovery. The RPE for the work performed were measured at the end of fatiguing handgrip exercise with Borg scale (range: 6-20).

Conclusion: The results of this study show significant correlation between RPE and blood lactate peak ($p<0.01$), RPE and MVG post exercise ($p<0.01$) and between RPE and Δ blood lactate (blood lactate post-blood lactate pre; $p<0.01$).

Keywords: Blood lactate; RPE; Fatigue

Introduction

The term fatigue, in healthy subjects, refers to any exercise induced loss of ability to exert force or power with a muscle or a muscle group [1,2]. Currently, the fatigue mechanism is generally considered a complex interaction between peripheral and central factors [3]. Nevertheless, following discovery of the monocarboxylate transporter [4], recent studies have suggested that lactate is an important fuel source during high-intensity exercise [5]. There is also evidence that reduction in pH [6] and blood flow [7] increases fatigue and that loss of homeostasis does not occur at the end of exercise [8].

Taekwondo is a marital art that had been growing in popularity even before its official inclusion in the Sydney 2000 Olympic Games. In the United States, approximately 1.5–2 million people practice martial arts [9], the most popular of which is. Athletes participate in full-sparring tournaments, in which points are awarded for punches and kicks to the head and torso [10,11].

Taekwondo is a popular organized activity, and recent studies have shown that related training activities, such as sparring and kicking drills, along with repetition can improve cardiovascular function, anaerobic power and strength [12–19]. In Taekwondo, competitors must be able to move at high speed and power, thus, taekwondo training may be a useful organized activity for improving essential elements of overall physical fitness [12,20]. In taekwondo competition the fatigue has large influence in performance [21–24]. When subject performed a maximal voluntary contraction, component fatigue is ascribed not only to peripheral factors but also to central factors that play role in the decline in force which results from a sub optimal output from the primary motor cortex, which ultimately leads to sub optimal firing rates of motor neurons [25]. When subject performed an incremental exhaustive exercise, rapidly decrease in muscle phosphocreatine and ATP, as well as an accumulation of metabolites like pyruvate and lactate [26].

To get information on the effort during vigorous exercise, there are different ways, such as the scale to measure subjective exertion, or the rating of perceived exertion (RPE), called the Borg scale [27]. This scale is an effective methods to quantify and monitor the intensity of the exercise [28]. This is primarily because of the strong association between RPE and such physiological variables such as heart rate, lactate, VO2max, ventilatory thresholds and respiratory rates [29–31].

Exhaustive exercise training especially in non-professional and untrained athletes cause oxidative stress associated with inflammatory response s, which is the cause for the muscle cell membrane damage observed in this sort of high-intensity and exhaustive activity and exercise. It is well known that exhaustive exercise result membrane cell damage to or inflammatory responses into the muscle cells [32–34]. The strenuous and exhaustive activity-induced muscular injury and damage has been related with oxidative stress, inflammation and an increase in the pro-inflammatory mediators [35]. This increase in oxidative stress related with strenuous exercise increases inflammatory cytokines and marker include hs-CRP, IL-6, and TNF-alpha, among others [33].

Mechanical and metabolic stresses caused by vigorous training and competitive running may result to fatigue (increased lactate) and change in some biochemical indicators include enzymes (e.g., creatine kinase) to the serum [36].

Numerous studies involving resistance exercise [37–39] have demonstrated strong associations between the Borg scale RPE and intensity indices such as myoelectric activity, the total load and the percentages of the 1RM. These associations suggest an effective use of a perceived exertion scale in determining intensities of exercises using external resistance.

Handgrip strength is a general term used in clinical [40–42] and occupational [43–45] settings and by strength athletes [46–48]. It refers to the muscular strength and force that can be generated by the hands. The strength of a handgrip is the result of the maximum force that the subject is able to exert under normal biokinetic conditions through the voluntary flexion of all finger joints, thumbs, and wrists [49]. Factors that are considered during these activities include the absolute level of strength necessary to perform the tasks and the fatigue experienced by the muscles responsible for these movements [50]. Several sporting activities require the maintenance of adequate levels of handgrip strength to maximize control and task performance and decrease injury risk [50].

Recent reports have described how lactate released from ischemic muscle may contribute to ischemic pain by acting on sensory neurons innervating muscles [51,52], while lactate was also shown to cause an increase in blood pressure through activation of groups III and IV afferent muscles (i.e., muscle metaboreflex) [53, 54].

The aim of this study was to investigated the relationship concerning RPE and increase in blood lactate level after fatiguing handgrip exercise, and the decrease in maximal voluntary grip (MVG) between taekwondo athletes and sedentary subjects. Moreover we investigated if the relationship between RPE and blood lactate is different between athletes and non-athletes.

Methods

Participants

Twelve right-handed [55] male taekwondo athletes (age: 26.5 ± 5.0 years) and 12 matched controls (age: 25.5 ± 4.8 years) were recruited (Table 1). A preliminary analysis was conducted to ascertain that there were no differences for age and anthropometric characteristics between the groups. The athletes were enrolled in a taekwondo club of Foggia (Italy). They were regularly competing at the national and international levels and undergoing a training regimen of at least five 2-hr sessions week-1 for the previous 10 years.

The controls declared to be not engaged in amateur or competitive sports. The local Institutional Ethics Committee approved the study. Participants were provided both written and oral information regarding the possible risks and discomforts and were ensured that they were free to withdraw from the study at any time.

Protocol

Subjects sat in an armchair with their left hand relaxed in the prone position and their right hand holding a hand dynamometer. Subjects were asked to grip the dynamometer with their right hand, producing a isometric contraction.

	Athletes	Non-athletes	P-value
Age	26.5 ± 5.0	25.5 ± 4.8	>0.05
Height	176.5 ± 6.6	181.4 ± 8.0	>0.05
Body mass	72.4 ± 3.6	78.9 ± 3.1	>0.05

Table 1: Anthropometric characteristics: Values are in mean (M) ± standard deviation (SD).

Maximal voluntary grip (MVG) was recorded as the highest of the 3 values of maximal isometric force generated from the dominant hand using hand grip dynamometer (Biopac systems, MP 100). Peak force was measured on the oscilloscope screen and, after a subsequent rest, subjects were asked to reproduce 30% of their MVG for 4 s, then relax for 2 s, and then repeat this sequence for 10 minutes. The force trace on the oscilloscope allowed the subject to visually control the force exerted and keep it at the requested level. During all the exercises, the experimenters encouraged the subject and assured that the requested level of force was maintained. Data were acquired at 500 Hz via a Biopac MP 100 system. Biopac Acqknowledge 4.1 software was used to determine the peak force amplitude for each trial [56]. Capillary blood lactate was measured at rest (pre-test), at the end (0 min) as well as 3 and 10 min of the recovery by using a "Lactate Pro" portable lactate analyser [57–59].

The RPE, subjective perception of effort (RPE), for the work performed were measured at the end of fatiguing handgrip exercise with Borg scale (range:6-20) [60,61]. Written instructions on the use of the Borg scale were read to the participants prior to the test and participants were used to the method on a daily basis for at least one month before starting the study.

Statistical Analysis

The R Project for Statistical Computing software (version 3.1.0) was used for statistical analyses. Means and SDs were calculated for each of the analyzed variables and statistical significance was set at $p \leq 0.05$. The Shapiro-Wilk test was used to verify the normal distribution of variables. T-test was used to compare the differences in RPE between groups. Blood lactate data collected from the participants were compared by means of two-way repeated measure ANOVA, followed by Tukey's multiple comparison post hoc test. Pearson product-moment correlation was performed to ascertain the relationship between RPE and blood lactate measured at the end of fatiguing exercise (peak), and between RPE and maximal voluntary grip measured at the end of fatiguing exercise. Furthermore Pearson product-moment correlation was performed to ascertain the relationship between RPE and the increase in blood lactate (Δ) (blood lactate peak-blood lactate rest). Linear regression was performed to investigate the relationship between RPE and Δ peak force (peak force pre-peak force post).

Citation: Moscatelli F, Messina G, Valenzano A, Petito A, Triggiani AI, et al. (2015) Relationship between RPE and Blood Lactate after Fatiguing Handgrip Exercise in Taekwondo and Sedentary Subjects. Biol Med (Aligarh) 1: S3008. doi:10.4172/0974-8369.1000s3008

Results

No discomfort or adverse effects during fatiguing handgrip exercise were noticed or reported. The MVG measured by hand-grip transducer before fatiguing exercise, as expected was higher in athletes than in non-athletes, but there are no differences between groups.

However significant differences in MVG between groups emerged after exercise (p<0.05) (Figure 1).

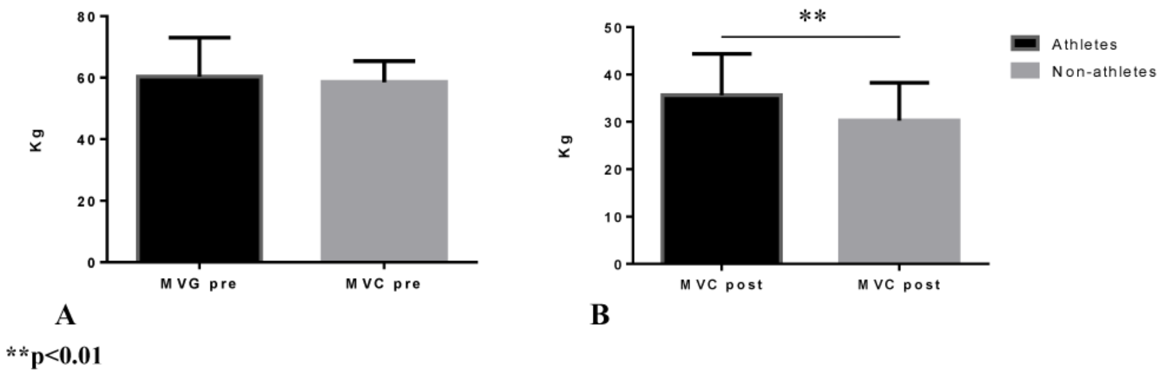

Figure 1: Changes in maximal voluntary grip between groups. A) Differences in MVG before fatiguing exercise. B) Differences in MVG after fatiguing exercise. **p<0.01

Compared to pre-exercise values blood lactate strongly increased at the end of exercise in athletes group (pre: 2.1 mmol/l ± 0.4; post: 4.2 mmol/l ± 0.2; p<0.001; +50%) and in non-athletes (pre: 1.9 mmol/l ± 0.2; post: 6.2 mmol/l ± 1.8; p<0.001; +69%), decline after 3' min (athletes: 3.5 mmol/l ± 0.5; non-athletes: 4.0 mmol/l ± 0.6), and recovered to the pre-exercise value within 10 min (athletes: 2.1 mmol/ ± 0.4; non-athletes 2.0 mmol/l ± 0.6). Blood lactate values showed differences between two groups. In particular at the end of the exercise non athletes showed higher value of blood lactate compared to athletes (6.2 mmol/l ± 1.8 vs 4.2 mmol/l ± 0.2; p<0.001). However after 3 minute of the end of the exercise, no differences emerged between two groups (p>0.05) (Figure 2).

Simultaneously blood lactate, from pre-exercise condition to post-exercise condition, increased 2.1 ± 0.4 mmol/l in taekwondo group and 4.3 ± 1.0 mmol/l in non-athlete group (p<0.01).

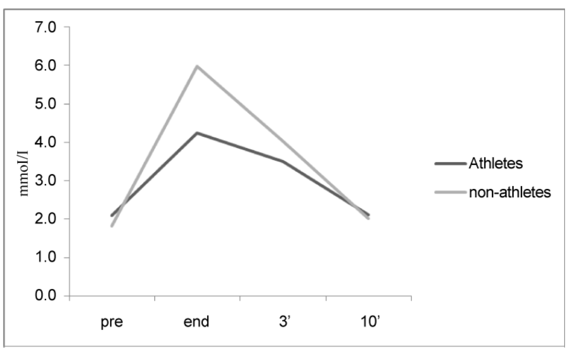

Figure 2: Changes in blood lactate level at rest (pre), at the end (0 min) as well as 3 and 10 min of the recovery, between two groups.

The RPE value, collected at the end of the fatiguing handgrip exercise, show significant differences between athletes and non athletes respectively (14.1 ± 1.2 vs 16.7 ± 1.0; p<0.01).

Pearson product-moment show significant positive correlation between RPE and blood lactate peak (r= 0.652; p<0.001), significant negative correlation between RPE and MVG post fatiguing exercise (r= -0.534; p<0.001), and positive correlation between RPE and blood lactate increase (Δ= blood lactate pre-blood lactate post) (r= 0.673; p<0.001).

Furthermore significant negative correlation emerged between blood lactate peak and MVG post (r= -0437; p<0.05). Linear regression (Figure 3) show significant relationship between RPE and Δ peak force (R2=0.40; F=14.38; p<0.01).

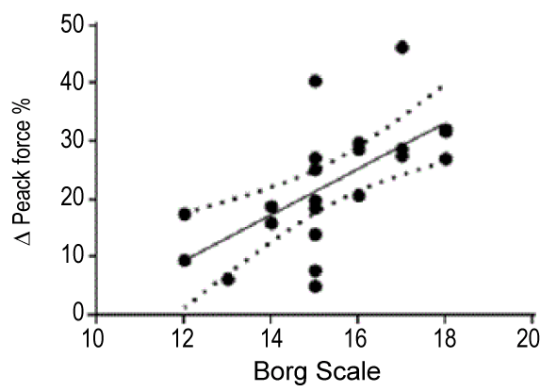

Figure 3: Linear regression analysis between REP (Borg Scale) and Δ Peak force

Discussion

The aim of this study was to analyze the differences in physiological aspect, in particular the differences in RPE, peak force and blood lactate between taekwondo athletes and non-athletes. The major findings of the present study were that: a) after fatiguing exercise significant differences emerged between athletes and non-athletes in RPE, MVG and blood lactate values; b) significant overall correlation emerged between RPE and blood lactate collected after fatiguing test exercise, and between RPE and Δ peak force. The major conclusion drawn from this study was that handgrip strength was significantly different between athletes and non-athletes.

The present study shows that a voluntary sub-maximal tonic contraction is associated with a small but significant increase in blood lactate in each group. According with literature, the small increase in blood lactate found in our subject is a consequence of the relatively small muscle mass involved in the exercise coupled to the low-level work done during grip [62–65]. As we expected blood lactate increase (peak) was significantly higher in non-athletes than athletes. Furthermore athletes show also higher MVG than non-athletes before and after fatiguing exercise ($p<0.001$).

During and following a sustained maximal effort there is a reduction in the ability of the muscles to generate force. A contribution of central mechanisms to this fatigue is indicated by a progressive increase in superimposed twitch size during the sustained effort and a reduced voluntary activation in the recovery period afterward. Strength exercises are usually characterized by high energy demand and restricted blood flow during time under tension. Thus, due to the hypoxic environment experienced by the exercising muscle, anaerobic energy metabolism plays an important role during exercise. As a result, lactate production is increased in the working muscles, especially in type II muscle fibers, and consequently blood lactate concentration increases. Numerous studies evidence has led to the suggestion that there is no single mechanism but multiple mechanism of fatigue, of which the most significant include depletion of ATP (adenosine triphosphate) and overproduction of reactive oxygen species [66, 67]. Other cause include local inflammatory reactions, altered calcium levels, modified bioenergetic pathways, or impaired endocrine function of muscle cell [68].

Pearson product-moment analysis show significant positive overall correlation between RPE and blood lactate peak ($p<0.01$). This results show that the increase in blood lactate seems to influence the RPE. The subjects who perceived greater effort show also greater blood lactate values. This results was confirmed by the significant positive correlation between RPE and blood lactate Δ ($p<0.01$). Higher RPE values are associated with higher blood lactate values. Our data are in line with literature. In fact After 3 fight simulations, Franchini et al [69] only verified a strong correlation between the RPE (RPE 6-20 scale) and blood lactate peak ($r = 0.81$) in the first fight. In other study, Serrano et al [70] while investigating the perception of effort in relation to the competition, inferred a significant correlation between the RPE (RPE 6-20 scale, mean=14.6; variation between 11 and 18) and the Lactate peak ($r =0.63$, $p<0.01$) and between the RPE and the variation (Δ) of blood lactate ($r=0.64$, $P<0.05$). Based on those findings, the current study hypothesized the existence of a relation between RPE, blood lactate and MVG after fatiguing exercise. In fact our results are in line with previously published article, were is reported that RPE can be affected by physiological factors that can diminish the sense of exertion [16].

Conclusion

In conclusion, given that RPE is a non-invasive method to investigate the perceived exertion, and given that our results indicate that there are correlation between RPE and blood lactate level, and that this condition is reflected on MVG performance, it can be used for the evaluation of the workload, both in training and in particular during competitions in taekwondo athletes.

References:

1. Ishii H, Nishida Y (2013) Effect of Lactate Accumulation during Exercise-induced Muscle Fatigue on the Sensorimotor Cortex. J Phys Ther Sci 25: 1637-1642.
2. Taylor JL, Gandevia SC (2008) A comparison of central aspects of fatigue in submaximal and maximal voluntary contractions. J Appl Physiol (1985) 104: 542-550.
3. Meeusen R, Watson P, Hasegawa H, Roelands B, Piacentini MF (2007) Brain neurotransmitters in fatigue and overtraining. Appl Physiol Nutr Metab 32: 857-864.
4. Garcia CK, Goldstein JL, Pathak RK, Anderson RG, Brown MS (1994) Molecular characterization of a membrane transporter for lactate, pyruvate, and other monocarboxylates: implications for the Cori cycle. Cell 76: 865-873.
5. Brooks GA (1991) Current concepts in lactate exchange. Med Sci Sports Exerc 23: 895-906.
6. Nielsen OB, de Paoli F, Overgaard K (2001) Protective effects of lactic acid on force production in rat skeletal muscle. J Physiol 536: 161-166.
7. Wigmore DM, Propert K, Kent-Braun JA (2006) Blood flow does not limit skeletal muscle force production during incremental isometric contractions. Eur J Appl Physiol 96: 370-378.
8. Tucker R, Marle T, Lambert EV, Noakes TD (2006) The rate of heat storage mediates an anticipatory reduction in exercise intensity during cycling at a fixed rating of perceived exertion. J Physiol 574: 905-915.
9. Woodward TW (2009) A review of the effects of martial arts practice on health. WMJ 108: 40-43.
10. Estevan I, Jandacka D, Falco C (2013) Effect of stance position on kick performance in taekwondo. J Sports Sci 31: 1815-1822.
11. Kazemi M (2012) Relationships between injury and success in elite Taekwondo athletes. J Sports Sci 30: 277-283.
12. Kazemi M, De Ciantis MG, Rahman A (2013) A profile of the Youth Olympic Taekwondo Athlete. J Can Chiropr Assoc 57: 293-300.
13. Kazemi M, Perri G, Soave D (2010) A profile of 2008 Olympic Taekwondo competitors. J Can Chiropr Assoc 54: 243-249.
14. Kazemi M, Waalen J, Morgan C, White AR (2006) A profile of olympic taekwondo competitors. J Sports Sci Med 5: 114-121.
15. Aggeloussis N, Gourgoulis V, Sertsou M, Giannakou E, Mavromatis G (2007) Repeatability of electromyographic waveforms during the naeryo chagi in taekwondo. J Sports Sci Med 6: 6-9.
16. Haddad M, Chaouachi A, Castagna C, Wong del P, Behm DG, et al. (2011) The construct validity of session RPE during an intensive camp in young male Taekwondo athletes. Int J Sports Physiol Perform 6: 252-263.
17. Schlüter-Brust K, Leistenschneider P, Dargel J, Springorum HP, Eysel P, et al. (2011) Acute injuries in Taekwondo. Int J Sports Med 32: 629-634.
18. Bridge CA, Ferreira da Silva Santos J, Chaabène H, Pieter W, Franchini E (2014) Physical and physiological profiles of taekwondo athletes. Sports Med 44: 713-733.
19. Kim HB, Jung HC, Song JK, Chai JH, Lee EJ (2015) A follow-up study on the physique, body composition, physical fitness, and isokinetic strength of female collegiate Taekwondo athletes. J Exerc Rehabil 11: 57-64.
20. Caddick N, Smith B (2014) The impact of sport and physical activity on the well-being of combat veterans: A systematic review. Psychol Sport Exerc 15: 9–18.

21. Lin WL, Yen KT, Lu CYD, Huang YH, Chang CK (2006) Anaerobic capacity of elite Taiwanese Taekwondo athletes. Sci Sport 21:291–293.
22. Toskovic NN (2001) Alterations in selected measures of mood with a single bout of dynamic Taekwondo exercise in college-age students. Percept Mot Skills 92: 1031-1038.
23. Bridge CA, McNaughton LR, Close GL, Drust B (2013) Taekwondo exercise protocols do not recreate the physiological responses of championship combat. Int J Sports Med 34: 573-581.
24. Seo MW, Jung HC, Song JK, Kim HB (2015) Effect of 8 weeks of pre-season training on body composition, physical fitness, anaerobic capacity, and isokinetic muscle strength in male and female collegiate taekwondo athletes. J Exerc Rehabil 11: 101-107.
25. Taylor JL, Butler JE, Allen GM, Gandevia SC (1996) Changes in motor cortical excitability during human muscle fatigue. J Physiol 490 2: 519–528.
26. Bangsbo J (1998) Quantification of anaerobic energy production during intense exercise. Med Sci Sports Exerc 30: 47-52.
27. Spielholz P (2006) Calibrating Borg scale ratings of hand force exertion. Appl Ergon 37: 615-618.
28. Soriano-Maldonado A, Romero L, Femia P, Roero C, Ruiz JR, et al. (2014) A learning protocol improves the validity of the Borg 6-20 RPE scale during indoor cycling. Int J Sports Med 35: 379-384.
29. Chen MJ, Fan X, Moe ST (2002) Criterion-related validity of the Borg ratings of perceived exertion scale in healthy individuals: a meta-analysis. J Sports Sci 20: 873-899.
30. Groslambert A, Mahon AD (2006) Perceived exertion : influence of age and cognitive development. Sports Med 36: 911-928.
31. Utter AC, Kang J, Nieman DC, Dumke CL, McAnulty SR (2006) Validation of Omni scale of perceived exertion during prolonged cycling. Med Sci Sports Exerc 38: 780-786.
32. Suzuki K, Yamada M, Kurakake S, Okamura N, Yamaya K, et al. (2000) Circulating cytokines and hormones with immunosuppressive but neutrophil-priming potentials rise after endurance exercise in humans. Eur J Appl Physiol 81: 281-287.
33. Powers SK, Jackson MJ (2008) Exercise-induced oxidative stress: cellular mechanisms and impact on muscle force production. Physiol Rev 88: 1243-1276.
34. Gomez-Cabrera MC, Borrás C, Pallardó FV, Sastre J, Ji LL, et al. (2005) Decreasing xanthine oxidase-mediated oxidative stress prevents useful cellular adaptations to exercise in rats. J Physiol 567: 113-120.
35. Kasapis C, Thompson PD (2005) The effects of physical activity on serum C-reactive protein and inflammatory markers: a systematic review. J Am Coll Cardiol 45: 1563-1569.
36. Cooke M, Iosia M, Buford T, Shelmadine B, Hudson G, et al. (2008) Effects of acute and 14-day coenzyme Q10 supplementation on exercise performance in both trained and untrained individuals. J Int Soc Sports Nutr 5:8.
37. Buckley JP, Borg GA (2011) Borg's scales in strength training; from theory to practice in young and older adults. Appl Physiol Nutr Metab 36: 682-692.
38. Lagally KM, Robertson RJ, Gallagher KI, Goss FL, Jakicic JM, et al. (2002) Perceived exertion, electromyography, and blood lactate during acute bouts of resistance exercise. Med Sci Sports Exerc 34: 552-559.
39. Lagally KM, Robertson RJ (2006) Construct validity of the OMNI resistance exercise scale. J Strength Cond Res 20: 252-256.
40. Gülke J, Wachter NJ, Katzmaier P, Ebinger T, Mentzel M (2007) Detecting submaximal effort in power grip by observation of the strength distribution pattern. J Hand Surg Eur Vol 32: 677-683.
41. Sande LP, Coury HJ, Oishi J, Kumar S (2001) Effect of musculoskeletal disorders on prehension strength. Appl Ergon 32: 609-616.
42. Tredgett MW, Davis TR (2000) Rapid repeat testing of grip strength for detection of faked hand weakness. J Hand Surg Br 25: 372-375.
43. Eksioglu M (2004) Relative optimum grip span as a function of hand anthropometry. Int J Ind Ergon 34:1–12.
44. Nicolay CW, Walker AL (2005) Grip strength and endurance: Influences of anthropometric variation, hand dominance, and gender. Int J Ind Ergon 35:605–618.
45. Watanabe T, Owashi K, Kanauchi Y, Mura N, Takahara M, et al. (2005) The short-term reliability of grip strength measurement and the effects of posture and grip span. J Hand Surg Am 30: 603-609.
46. Leyk D, Gorges W, Ridder D, Wunderlich M, Rüther T, et al. (2007) Hand-grip strength of young men, women and highly trained female athletes. Eur J Appl Physiol 99: 415-421.
47. Duque J, Masset D, Malchaire J (1995) Evaluation of handgrip force from EMG measurements. Appl Ergon 26: 61-66.
48. Innes E (1999) Handgrip strength testing: A review of the literature. Aust Occup Ther J 46:120–140.
49. Koley S, Singh AP (2009) An association of dominant hand grip strength with some anthropometric variables in Indian collegiate population. Anthropol Anz 67: 21-28.
50. Blackwell JR, Kornatz KW, Heath EM (1999) Effect of grip span on maximal grip force and fatigue of flexor digitorum superficialis. Appl Ergon 30: 401-405.
51. Immke DC, McCleskey EW (2001) Lactate enhances the acid-sensing Na + channel on ischemia-sensing neurons. Nat Neurosci 4: 869-870.
52. Green JM, Bishop PA, Muir IH, McLester JR Jr, Heath HE (2000) Effects of high and low blood lactate concentrations on sweat lactate response. Int J Sports Med 21: 556-560.
53. Thomas GD, Segal SS (2004) Neural control of muscle blood flow during exercise. J Appl Physiol (1985) 97: 731-738.
54. Phypers B, Pierce JMT (2006) Lactate physiology in health and disease. Contin Educ Anaesth Crit Care Pain 6:128–132.
55. Oldfield RC (1971) The assessment and analysis of handedness: the Edinburgh inventory. Neuropsychologia 9:97–113.
56. Life F (2000) Acq Knowledge Software Guide AcqKnowledge Software Guide. Channels
57. Håkanson H, Kyröläinen M, Mattiasson B (1993) Portable system for continuous ex vivo measurements of lactate. Biosens Bioelectron 8: 213-217.
58. Mamen A, Tillaar R Van Den (2009) Estimating the Maximal Lactate Steady State Power from an Incremental Test Using Lactate Pro ® LP1710. Int J Appl Sport Sci 21:74–85.
59. McLean SR, Smith DJ (2004) Comparison of the Lactate pro and the YSI 1500 sport blood lactate analyzers. IJASS: 22–30.
60. Borg E, Kaijser L (2006) A comparison between three rating scales for perceived exertion and two different work tests. Scand J Med Sci Sports 16: 57-69.
61. Borg GA (1982) Psychophysical bases of perceived exertion. Med Sci Sports Exerc 14: 377-381.
62. Coco M, Alagona G, Perciavalle V, Cavallari P, et al. (2014) Changes in cortical excitability and blood lactate after a fatiguing hand-grip exercise. Somatosens Mot Res 31: 35-39.
63. Coco M, Alagona G, Rapisarda G, Costanzo E, Calogero RA, et al. (2010) Elevated blood lactate is associated with increased motor cortex excitability. Somatosens Mot Res 27: 1-8.
64. Perciavalle V, Coco M, Alagona G, Maci T, Perciavalle V (2010) Gender differences in changes of motor cortex excitability during elevated blood lactate levels. Somatosens Mot Res 27: 106-110.
65. Alagona G, Coco M, Rapisarda G, Costanzo E, Maci T, et al. (2009) Changes of blood lactate levels after repetitive transcranial magnetic stimulation. Neurosci Lett 450: 111-113.
66. Koch AJ, Pereira R, Machado M (2014) The creatine kinase response to resistance exercise. J Musculoskelet Neuronal Interact 14: 68-77.
67. Sargeant AJ (2007) Structural and functional determinants of human muscle power. Exp Physiol 92: 323-331.
68. Finsterer J (2012) Biomarkers of peripheral muscle fatigue during exercise. BMC Musculoskelet Disord 13: 218.
69. Franchini E, Takito MY, Lima JRP, Haddad S, Kiss MAPD, et al. (1998) Características fisiológicas em testes laboratoriais e resposta da

Citation: Moscatelli F, Messina G, Valenzano A, Petito A, Triggiani AI, et al. (2015) Relationship between RPE and Blood Lactate after Fatiguing Handgrip Exercise in Taekwondo and Sedentary Subjects. Biol Med (Aligarh) 1: S3008. doi:10.4172/0974-8369.1000s3008

concentração de lactato sangüíneo em três lutas em judocas das classes juvenil-A, júnior e sênior. Rev Paul Educ Física 12:5–16.

70. Serrano MA, Salvador A, González-Bono EG, Sanchís C, Suay F (2001) Relationships between recall of perceived exertion and blood lactate concentration in a judo competition. Percept Mot Skills 92: 1139-1148.

This article was originally published in a special issue, entitled: **"Human Biology and Education",** Edited by Saurabh Ram Bihari Lal Shrivastava