Metabolic Markers in Jamaican Male Sprinters

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ABSTRACT

Studies have revealed that metabolic adaptations represent a significant contributor to successful sprinting performance. This study investigated biochemical markers of muscle metabolism in Jamaican males following a medium sprint expecting a distinction among elite, sub-elite (based on previous achievements) and control groups. Blood lactate was measured before (zero) and after (three, eight and 15 minutes) a 350m sprint. Serum creatine kinase and lactate dehydrogenase determination was done before (zero) and after (30 minutes) the sprint. One way analysis of variance revealed statistically significant differences among the groups for pre-exercise $p = .015$, and post-exercise $\pi = .001$ lactate dehydrogenase levels; post-exercise $p = .025$ creatine kinase levels; and 350m sprint velocity $p < .001$. Positively correlated for the two groups of athletes were velocity and peak blood lactate $p < .001$. Peak blood lactate, serum creatine kinase and lactate dehydrogenase provided distinctions in performance. The authors conclude with a set of practical implications for their findings including that serum levels of key muscle enzymes provide a basis for the classification of fitness levels and the muscle's response to exercise.

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Introduction

In recent decades there has been significant accumulation of scientific data regarding athlete physiology[1] and the link to performance[2]. As such, deciphering the underlying biochemical characteristics that are significant to training and performance in particular groups of persons will serve to inform the literature and provide greater understanding of the molecular mechanisms involved[3].

Studies have revealed that metabolic adaptations represent a significant contributor to successful sprinting performance, highlighting major changes taking place with respect to the serum enzymes creatine kinase (CK) and lactate dehydrogenase (LDH) [4]. The activity of CK and LDH measured by needle biopsy show differences in behaviour before and after training with changes dependent on exercise protocol, intensity and level of training. These adaptations are seen more so with CK than LDH[5] but in both cases point to serum levels of CK and LDH being good indicators of performance in well-trained sprinters[6].

Numerous studies have evaluated changes in CK following exercise, and it differs widely according to the exercise protocol[7, 8, 9]. Total CK and LDH serum levels depend on age, gender, race, muscle mass, physical activity, and climatic conditions[10]. CK monitoring allows us to identify adequate muscular recovery and subclinical muscular pathologies while LDH monitoring lends itself to understanding the muscle's response to training[11, 12]. Research points to the increase in serum enzyme levels following eccentric exercise, marathon running and weight bearing exercises[12]. However, serum enzyme efflux following intense activity may just represent a disturbance of muscle energy processes[3].

With increasing exercise intensity the build-up of lactate in the blood is reflective of ATP resynthesis via anaerobic pathways[13]. While the highest blood lactate values (15-25mM) are usually seen three to eight minutes after an all-out exercise of 30 to 120 seconds[14]. Serum CK and LDH impact athletic performance and affect the buildup of lactate in the blood[15]. Blood lactate directly impacts sprinting performance as it provide an overview of the contracting muscle during supramaximal exercise and may differentiate between the ability to sustain sprinting performance at different levels[13 ,16] . The evaluation of blood lactate under simulated competition in well-trained athletes may therefore provide insight into muscle adaptation to sprinting.

Hence the researchers set out to evaluate the relationship between serum enzyme release and lactate levels in relation to sprinting in well-trained youth and junior male sprinters. Jamaican sprinters are renowned for performing at the highest level during international events like the Olympic Games and World Championships in Athletics[17], many of whom had their start at the national secondary schools' competition, hence exploring metabolic adaptations of serum enzymes and lactate response during sprinting in a young Jamaican cohort may support a basis for classification based on performance of athletes into elite (EG) and sub-elite (SEG) groups.

Methods

The study was carried out with male track and field sprinters (n = 30) who represented their respective schools at the national secondary schools' championships, some of whom had represented Jamaica regionally (Caribbean) and internationally. The participants were pre-divided based on previous athletic achievements into the elite group (EG), (n =15) and the sub-elite group (SEG), (n = 15). The EG consisted of athletes who made the finals at the secondary school championship for their respective sprint event and/or were national youth representatives, while the SEG consisted of athletes who did not make the finals of their respective event and have never represented Jamaica.

Males slightly older but within the youth range who were not a part of any structured exercise programme served as controls (CG) (n = 30).

This study involving voluntary human participants was conducted with adherence to international ethical standards (Declaration of Helsinki). The University of the West Indies Ethics Committee granted Institutional and Ethical approval (Reference: ECP 227, 2009/2010). Participants under 18 years old provided written assent along with parental consent, and the participants of 18 years and older provided informed consent documentation[18].

Each participant followed the protocol below[5, 13, 14].

- BMI assessment; weight in kilograms divided by height in metres squared (kg/m^2)[19].
- Measurement of resting levels of lactate and serum CK and LDH.
- Performance exercise test of 350m at maximal intensity.

After the sprint, under passive recovery mode, we measured:

- post-exercise blood lactate at three, eight and fifteen minutes to determine peak blood lactate value;
- post-exercise CK and LDH at thirty minutes.

Blood lactate was measured from the fingertips (capillary) with a handheld meter (*Lactate Plus* ~ 7µl), while blood was taken from the antecubital vein using non-heparinized tubes for spectrophotometric determination of serum CK (EC 2.7.3.2) and LDH (EC1.1.1.27) activity using Enzymatic Assay Kits (Bioo Scientific Corp. TX, USA). Sampling was carried out in the afternoon between 14:00 and 17:00.

Statistical analyses of the data were done using Statistical Package for the Social Sciences, SPSS 21.0, IBM, New York, USA. Data analysis using Independent T-test, One-way Analysis of Variance (ANOVA) and Correlations. Statistical significance of comparisons was weighted at $p \leq .05$.

Results

The findings of this investigation are summarised in Tables 1 and 2. Peak blood lactate was determined as the highest blood lactate value at three, eight or fifteen minutes after the 350m sprint. The EG had the lowest resting blood lactate (1.06 ± 0.54 mM) and highest value for peak blood lactate (18.9 ± 5.1 mM) of the three (3) groups.

All groups saw a significant increase in serum enzyme levels following exercise. Using the paired samples t-test there was a significant difference between pre- and post-exercise levels of CK t (59) = -4.08, p <.001 and LDH, t (59) = -5.96, p <.001 for the sample.

Correlational analysis was done for peak blood lactate, velocity, and post-exercise serum levels of CK and LDH. For the athletes (EG and SEG), statistically significant findings emerged where velocity and peak blood lactate were positively correlated r (28) = .70, p < .001, velocity was also positively correlated with pre- r (28) = .40, p = .04 and post-exercise LDH r (28) = .40, p = .04. Post-exercise CK and LDH were also positively correlated r (28) = .50, p = .012. No significant correlations were noted for the CG.

Discussion

The evaluation of serum enzyme levels and peak blood lactate in well – trained junior male athletes following a medium sprint provides insight into training and muscle adaptation to sprinting performance. The predictive quality of these biochemical markers measured under simulated race conditions was underscored by this study.

Previous studies have highlighted the significance of serum CK and LDH[7] and blood lactate values[16] in relation to a medium sprint.

CK showed a greater percentage increase from pre-exercise levels than LDH, which may highlight the smaller size of the CK (~86kDa) protein compared to LDH (~140kDa)[20]. The responsive rise in CK levels indicate that the exercise was strenuous enough to go beyond the muscles threshold for sprint intensity[21]. The percent increase over pre exercise levels of CK and LDH was significant across the three (3) groups; with the EG differing from the SEG, and both groups of athletes having a significantly lower percentage increase than the CG.

Serum enzyme levels are markers of the functional status of the muscle tissue[10] as expected the trained muscles in athletes were expected to be more functionally efficient than muscles not similarly trained. A similar study

Table 1: Measured characteristics of participants

Characteristic	EG (*n* = 15)	SEG (*n* = 15)	CG (*n* = 30)
Age (years)	17.4 ± 1.4^^	17.0 ± 1.4**	21.3 ± 1.8^^,**
Weight (kg)	73.0 ± 6.2*	64.7 ± 5.7*,**	74.6 ± 15.8**
Height (cm)	180.2 ± 6.1	177.5 ± 5.6	180.8 ± 9.1
BMI (kg/m^2)	22.4 ± 1.8*	20.5 ± 1.6*,**	22.6 ± 3.2**
Velocity of 350m sprint (ms^1)	7.1 ±0.55^^	6.9 ±0.47**	5.7 ±0.76^^
PRE bLac$^-$ mM	1.1 ± 0.54	1.8 ± 1.3	1.1 ± 0.6
Peak POE bLac$^-$mM	18.9 ± 5.1	17.3 ± 4.2	18.4 ± 4.3

Data are presented as mean ±SD
EG – Elite Group
SEG – Sub-elite Group
CG - Control Group
PRE - Pre–exercise
POE – Post-exercise
BLac- - Blood lactate
* implies significance ($p \leq 0.05$) between EG and SEG
^^ implies significance ($p \leq 0.05$) between EG and CG
** implies significance ($p \leq 0.05$) between SEG and CG

highlighted a greater increase in CK serum levels in sedentary individuals than athletes following the same activity[10]. The EG displayed the lowest percentage increase of CK and LDH which may point to fewer traumas to the associated muscle tissues[21] and suggest a greater adaptation to the prescribed exercise or the muscle's greater efficiency.

Of note the SEG were significantly lighter in weight than the EG, which may suggest a lower muscle mass, despite being similar in age and exposed to similar training conditions. The EG and CG did not differ significantly in regards to their weight, which may suggest that the EG possess significant muscle mass which may counter any age difference between the two groups. How this difference may have affected the results for the serum enzyme levels is not clear and adds another variable to the equation.

Post-exercise serum levels for CK and LDH did not significantly distinguish the two groups of athletes (SEG and EG) but created a distinction between the athletes and the controls (CG). However, the percentage increase in serum levels provided a clear distinction among all groups; highlighting the muscle's actual response to concentric and eccentric loading on a flat surface[22].

Table 2: Descriptive values for percentage increase in serum enzyme levels at 30 minutes post exercise

Group	PRE CK (IU/L)	POE CK (IU/L)	% I	PRE LDH (IU/L)	POE LDH (IU/L)	% I
EG	140.5 ± 66.6	173.0 ± 90.9^^	25.4* ^^	129.1 ± 13.4	139.8 ± 14.3^^	9.4* ^^
SEG	140.4 ± 58.5	201.2 ± 106.9	41.3* **	130.4±18.6	145.2 ± 20.9**	12.0* **
CG	284.8 ± 85.5	429.3 ± 120.4^^	72.2 ^^ **	175.9±72.2	242.5 ± 96.8^^ **	48.1^^ **
F(2,57)		3.9	8.4×10^{-31}	5.7	15.3	2.1×10^{-32}
P		0.025	<0.001	0.005	<0.001	<0.001

Data are presented as mean ±SD
EG – Elite Group
SEG – Sub-elite Group
CG - Control Group
CK -Creatine Kinase
LDH - Lactate Dehydrogenase
PRE - Pre–exercise
POE – Post-exercise
% I- Percentage Increase
* implies significance ($p \leq 0.05$) between EG and SEG
^^ implies significance ($p \leq 0.05$) between EG and CG
** implies significance ($p \leq 0.05$) between SEG and CG

These results might be instructive as the data may provide insight into the muscle's physiological response to training status. As such CK and LDH may provide insight into the muscle's physiological response and may indicate training status. Some researchers argue that serum levels of these enzymes indicate muscular pathologies and serve as a marker for localised cell/tissue damage[23]. However, other studies highlight that enzyme efflux after exercise may be a normal physiological response to exercise stress and loading[3]. The higher post-exercise serum enzyme levels seen in the CG of untrained individuals may indicate that CK and LDH can be used to pinpoint individuals whose muscles have not adapted to the rigor of sprinting.

The anaerobic response or peak blood lactate following a medium sprint did not significantly distinguish the EG and SEG, or distinguish the athletes from the CG. Correlation data showed strong statistical significance for peak blood lactate and post-exercise LDH with a positive relationship. A strong correlation was also seen between peak blood lactate and sprinting velocity for both EG and SEG. Peak blood lactate was not correlated with any of the aforementioned variables for the CG. These results suggest that peak blood lactate may be indicative of actual performance in a 350m sprint in well-trained runners as also suggested by research[24].

Well-trained junior athletes exhibit differences in their biochemical response to simulated competitive sprinting. Peak blood lactate following sprinting is a robust correlate of performance, while the percentage change in serum levels of CK and LDH provide insight into the physiological response of the muscle tissue. These two variables are influenced by training and may provide a distinction among individuals.

Conclusions

This study explored the association between (a) CK and LDH serum levels and athletic achievement and (b) lactate levels and athletic performance. It was conducted with the athlete in mind. Measurements were done in the field during the meso-cycle of training under simulated competition and as such represents real rather than artificial results. While sprint performance may be influenced by various factors, this research provided a greater basis for the evaluation of serum enzyme levels of CK and LDH and blood lactate as important variables in assessing the training and competitive performance of athletes. Our results provide relevant data to the exploration of serum enzyme response following exercise in a less studied ethnic group[3] and counters the idea that biochemical markers are not applicable and robust parameters for assessing the metabolic exercise response.

Practical Implications

Our findings:

- Highlight the implications of training status for athletes of similar age and fitness level.
- Show that changes in serum levels of key muscle enzymes provide a basis for the classification of fitness levels and the muscle's response to exercise.
- Show that measurement of metabolic markers can be useful indicators for athletes and coaches in assessing performance and or improvements in performance in training or competition.
- Show that within a defined exercise protocol among persons of similar age and fitness level, CK and LDH serum levels are useful and distinguishing markers.
- Further work can then be undertaken in comparing the percentage change in serum enzymes CK and LDH following simulated competition over a medium sprint among particular groups of persons.

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