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Lactatemia during intermittent in-line and shuttle effort

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Article info

Abstract :

The aim of this study was to explore physiological adaptations and blood lactatemia during high-intensity intermittent exercise, highlighting the impact of changes in direction during shuttle exercise. Two protocols were compared: one in line and one in shuttle with different intensities. This research is of major interest for quantifying intermittent training, particularly in team sports, in order to improve athlete monitoring. The experimental study was carried out on a sample of 10 male subjects, S.T.P.S.A students at Mohamed Lamine Debaghine University. The results of the statistical analysis revealed that intermittent shuttle training influences athletes' performance differently from line training, and that changes in direction during the shuttle running protocol resulted in a significant increase in lactatemia.

Keywords: Lactate, Line intermittent training, Shuttle intermittent training

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1. Introduction

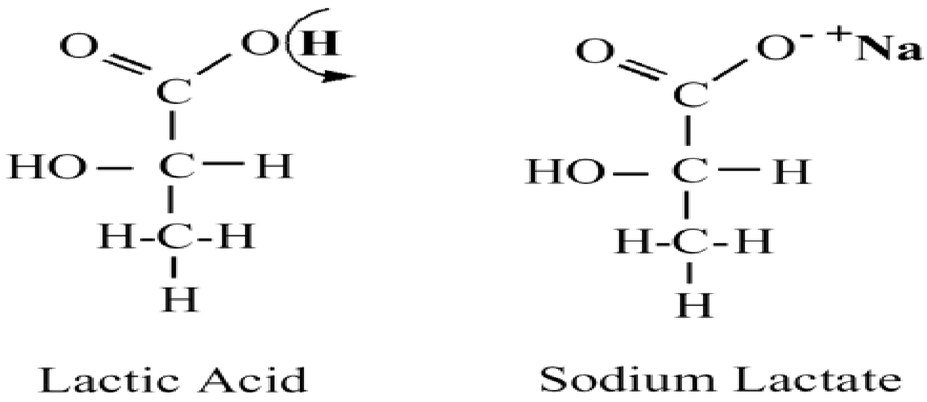
Several studies subsequent to the 19th century established that lactatemia [La] was a by-product of metabolism under conditions of O_2 limitation. For example, in 1891, Araki in Gladden L.B, (2001) reported elevated levels of [La] in the blood and urine of a variety of animals subjected to hypoxia. In the early 20th century, Fletcher and Hopkins found an accumulation of [La] in anoxia as well as after prolonged fatigue stimulation in amphibian muscle in vitro. Subsequently, based on the work of Fletcher and Hopkins (Fletcher W.M, Gowland F, 1907), as well as Hillandal, postulated that [La] increased during muscle exercise due to a lack of O_2 (Gladden L.B, 2001).

During muscle contraction, the repeated formation and rupture of actin and myosin bridges requires energy; this is released by the hydrolysis of ATP, present in very limited quantities in the muscle (around 4 to 6 mmol/kg of muscle), barely enough for a sprint start.

Continuing muscular exercise therefore requires the synthesis of ATP molecules as they are hydrolyzed. This is achieved via the following metabolic pathways: creatine phosphate hydrolysis, glycolysis (glucose catabolism) and glycogenolysis (glycogen catabolism), which take place in the cytosol without the direct use of oxygen, and oxidative phosphorylation, which takes place in the mitochondria. (Cazorla Gandal., 2001) During intense, short-duration exercise (e.g. 100, 200, 400 m sprint), anaerobic glycolysis synthesizes three net ATPs from one mole of glucose (C6 H12 O6) and forms two molecules of lactic acid (C3 H6 O3).

Since the pKa of lactic acid is less than 3 (Levraut J and al., 2011; Levraut J, 2009) at physiological pH, this acid splits, subsequently releasing the H^+ (proton) ion, and the remaining compound binds with sodium (Na^+) or potassium (K^+) ions to form a salt, lactate (fig.1)(Manolova A, 2012; David L and al., 2006).

Fig.1. Transformation of lactic acid into lactate salt



Lactate ($C3H5O3^-$) is the end product of anaerobic glycolysis, which supplies ATP from circulating glucose (C6H12O6) or muscle glycogen and takes place in the cytosol (Poortmans, 2009 in Péronnet F, 2013).

In conclusion, lactic acid and lactate are two distinct compounds, so it is more appropriate to speak of lactate than lactic acid, and to emphasize that lactate is nothing more than the indicator of ATP production by glycogenolysis and/or glycolysis (Cazorla Gandal., 2001).

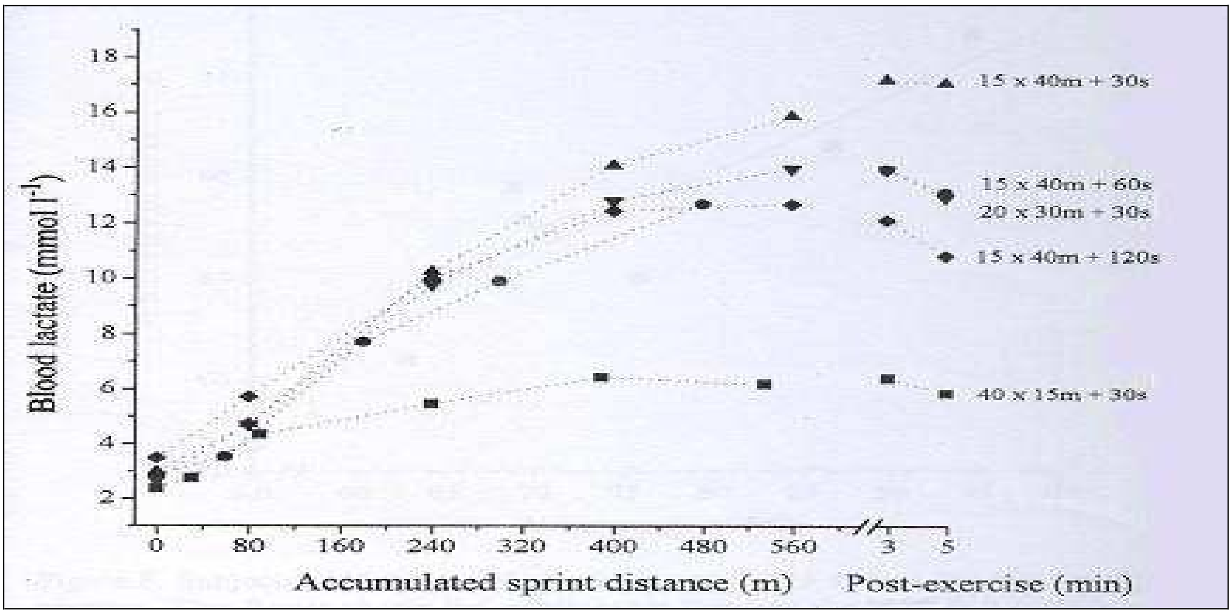
The concentration of heme lactate [La] remains one of the main indices of training control and load, although certain aspects of this physiological parameter, such as the concept of the anaerobic threshold, have been highly controversial. A stable value of [La] implies that lactate production and oxidation are equivalent. In fact, if lactate concentration, irrespective of its absolute value, remains constant over time, the type of work demanded of the organism from an energetic point of view is aerobic. Given the high individual variability of the anaerobic threshold value, it would, in theory, be desirable to determine a specific value for each athlete.

Nevertheless, the concept of an anaerobic threshold linked to a [La] set at 4 mmol l-1 is considered a sufficiently reliable index in practice (Bisciotti G.N and al., 2003).

The contribution of anaerobic metabolism to energy supply depends on work intensity and time (Bangsbo, 2008 in Dellal A, 2008). It is generally accepted that high-intensity exercise leads to significant lactate production in the muscle, and this lactate accumulation or associated muscle acidosis is a major determinant of fatigue (Fleming Nandal., 2017). At the start of a high-intensity effort, CPr provides the bulk of the energy supply (Jacques R, 2003), and the remaining anaerobic energy will be delivered by anaerobic glycolysis leading to lactate formation, but in the case of high-intensity intermittent training (HIIT), lactate formation will be low, given the short duration of these exercises (Balsom, 1995 in Jacques R, 2003, p38), and the lactate produced will be predominantly oxidized. (Hautier Candal, 2003)

Early studies on intermittent training focused on the evolution of blood lactate (Christensenandal., 1960; Margariaandal., 1969; Astrand and Rodhal, 1970; Fox and Mathews, 1977). Balsom P.D and al., (1995) found that for repetitions of 15 m sprints with a 30 s passive recovery, [La] ranged from 7 mmol/L to 15.5 mmol/L (fig.2) (Dellal A, 2008). On this subject, in a pre-experiment carried out in the laboratory, Arsac (1995) showed that 10 sprints of 5-s interspersed with 45-s of passive recovery resulted in neither fatigue nor significant accumulation of blood lactate (Hautier Candal., 2003).

Fig.2. Blood lactate concentration during and after sprint repetition



Source : Balsom P.D .(1995)

However, it should be remembered that intermittent training is now considered to be one of the most popular forms of training in team sports, particularly soccer (Dellal A,andal., 2010). Since analysis of the structure of intermittent sports activities has shown that they are characterized by frequent jumping, sprinting and changes of direction alternated with low-intensity walking or running (Haj Sassi Randal., 2009), high-intensity intermittent training, in its various forms, is today one of the most effective ways of improving cardiorespiratory and metabolic function and, in turn, the physical performance of athletes (Buchheit M and Laursen P.B, 2013). And in this respect, intermittent training has therefore been the subject of much work in recent years.

The organization of intermittent work consists of programmed work phases at higher or lower target intensities, interspersed with periods of active or passive recovery (Hervé A, Cometti G. 2007; Dellal Aandal., 2009). The individual programming of these sessions can simultaneously develop different physical qualities, depending on the choice of different characteristics of these intermittent exercises, such as the total duration of effort, the respective durations of effort and rest periods, or the intensity of the latter. The durations are directly linked to the intensity of the effort, but are also chosen with regard to the competitive activity (Buchheit M .2005 ; Ferre. J, Leroux. P. 2009).

Various studies have reported that high-intensity intermittent training (HIIT) is associated with the development of PMA (Hervé A and Cometti G, 2007) and the optimization of players' maximal oxygen uptake (VO2max) (Dellal Aandal., 2009), and that this training mode enables players to work longer than continuous exercise at the same intensity (Hervé A and Cometti G, 2007). However, given the short duration of intermittent exercise, intermittent training does not accumulate large quantities of lactate, and the lactate formed is metabolized during recovery (Dellal A, 2008).

The form of intermittent exercise represents the basis on which this study was founded: intermittent exercise can be performed either in line or with changes of direction. These changes can be half-turns, in which case they are defined as intermittent shuttle exercise, or lateral (Dellal A, 2008). In this case, according to analytical studies of the two activities (handball and soccer), the intermittent mode with change of direction suits them best, as long as the player during the match carries out courses at different intensities, with changes of direction (Ravier G and Bouzigon R, 2014; Dellal A and al., 2009).

The physiological responses of high-intensity in-line intermittent exercise have been the subject of several studies, and its impacts are well known, in contrast to shuttle intermittent, there are few studies that have highlighted it, and to our knowledge there has been no work that has addressed 10s-20s and 15s-30s intermittent.

In the present study, we compared the effects of intermittent 10s-20s effort at 100% and 110% of MAS in line and shuttle.

Dellal A, (2008, 2009) has already addressed in a comparative study, intermittent effort 10s-10s and 15s-15s in line and shuttle performed at 105%, 110% and 115% of MAS. The results showed significant differences between these two types of effort. Similarly, Buchheit M and al, (2010) argued in a comparative study between repeated line and shuttle sprint sequences, that 180° direction changes, may increase systemic metabolic load (i.e. cardiorespiratory and blood acidosis responses).

The aim of the present study is to explore physiological adaptations and even blood lactatemia during intermittent 10s-20s high-intensity exercise, and to shed light on the physiological impact of changes in direction during shuttle exercise, by comparing two types of protocol: one in line, and the other in shuttle with different intensities. Highlighting the physiological repercussions of changes in direction (deceleration and re-acceleration) during intermittent high-intensity shuttle effort is of great interest in quantifying intermittent training, given that quantifying training load is a recurring issue in team sports in order to improve athlete monitoring.

2. Method

2.1 Subject

Our experimental study was carried out on a sample of 10 healthy male subjects from the Département of Science and Technology of Physical Sports Activities, Mohamed Lamine Debaghine University, Sétif 2. These were young soccer players of a homogeneous level, with at least 8 hours of weekly practice.

Table 1. The anthropometric, physical and physiological characteristics of the group are as follows:

	Age	Weight	Height	MHR	RHR	HRR	[La]	MAS	LTim
Values S±D	22.5 ± 1.15	76.3 ± 4.6	178.7 ± 2	185.60 ± 7.41	56.6 ± 2.22	129 ± 8.95	1.87 ± 0. 2	17,75 ± 0.54	229 ± 31

MHR: Maximum Heart Rate , **RHR**: Recovery Heart Rate, **HRR**: Heart Rate Reserve, **[La]**: Lactatemia, **MAS**: Maximal Aerobic Speed,**LTim**: Limite Time in MAS

2.2 Measuring lactatemia in blood [La].

Lactatemia measurements using the Lactate Scoute+ lactometer (fig.3), were carried out before, during, at the end of and after 3 minutes of each intermittent effort session in line and shuttle, the Lactate scoute+ is a device that works by enzymatic determination and reflection photometry, its validation already demonstrated by Tanner. R.K and al, (2010), drops of blood are taken from the fingertip (0.2µl) after disinfecting it, then placed on strips inserted in the lactometer for analysis, and the results returned in mmol/L within 10 sec. Lactate Scout+ operates at temperatures of 5-45°C and up to 85% humidity.

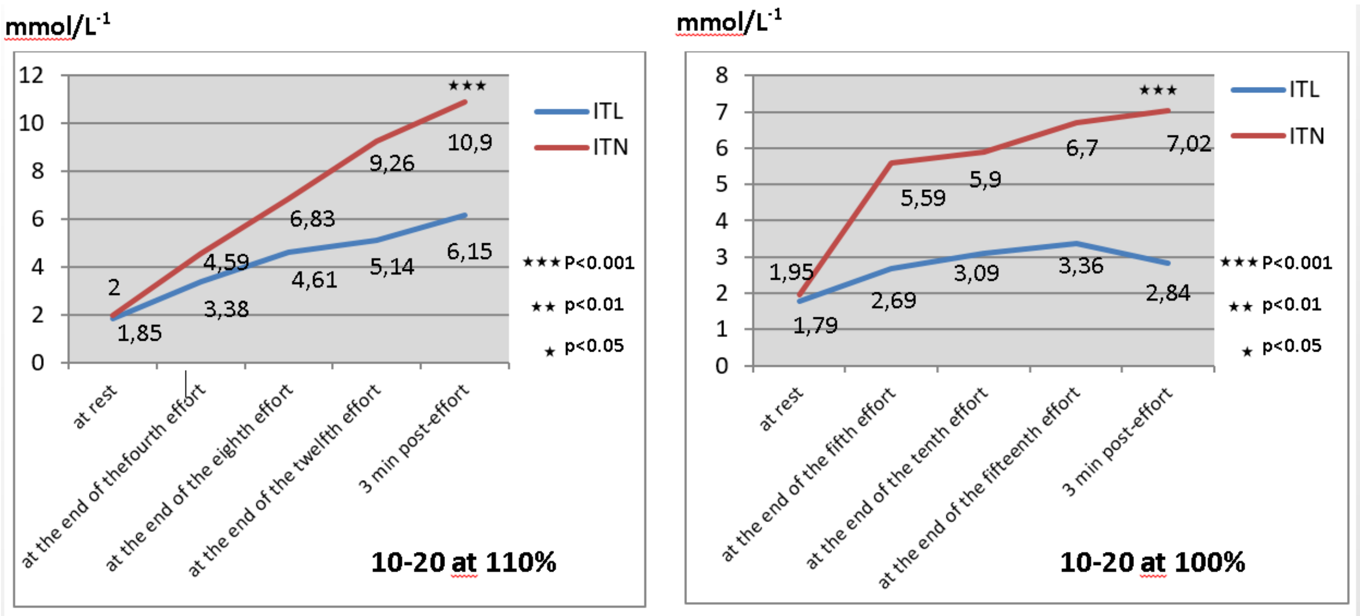
Fig.3. Scoute+ Lactate Lactometer

3. Results of the evolution of lactate concentration kinetics [La].

According to (fig.4), we observe that plasma lactate concentration increases significantly ($p<0.001$ and $p<0.01$), between the resting value and the value recorded at the third minute post-exercise, for the different sessions of intermittent effort 10s-20s in line and shuttle, at 100% and 110% of the MAS, however, for the sessions of intermittent effort in line, we observed a decrease in the value of plasma lactate concentration between the last efforts and the third minute post-exercise, with the presence of significant differences ($p < 0.05$) for the sessions at 100% of the MAS.

Comparing the plasma lactate concentration values recorded at the third minute post-exercise of the different intermittent effort sessions with those of the shuttle, the results indicate the presence of significant differences at $p < 0.001$ for the 10s-20s at 100% and 110%.

Fig.4. Comparison of changes in plasma lactate concentration [La].



4. Discussion

The results show significant differences ($p < 0.001$) in all 10s-20s intermittent exercise sessions performed at 100% and 110% of MAS (fig.6). The contribution of anaerobic metabolism to energy supply depends on the intensity and time of work (Bangsbo J, 2008 in Dellal A, 2008).

It is generally accepted that high-intensity exercise leads to significant lactate production in the muscle. At the start of high-intensity exercise, CPr provides the bulk of the energy supply (Jacques R, 2003), and the rest of the anaerobic energy will be delivered by anaerobic glycolysis leading to lactate formation, but in the case of HIE, lactate formation will be low, given the short duration of such intermittent exercise (Balsom P. D, 1995 in Jacques R, 2003), and most of the lactate produced will be oxidized (Hautier C and al., 2003), but the results of our study contradict these data. It seems that the changes of direction in the 10s-20s intermittent shuttle exercise sessions placed greater demands on the peripheral component, resulting in a higher energy expenditure than in the in-line course (Haj Sassi R and al., 2009; Flouris A.D and al, 2005), and that anaerobic metabolism strongly took its place in the energy supply as the [La] increased significantly (0.001), and the short recovery times between exercise did not allow oxidation of the lactate formed during exercise, similarly, the study by Buchheit M and al, (2012), contradicts our results when comparing repeated sprint sequences in line, and with changes of direction at 45°, 90°, 135°, the results revealed the existence of insignificant differences regarding the lactatemia variable, but on the other hand, the lactatemia rate during repeated sprint sequences with change of direction at 180°, is greater (+ 13%) than during sprint sequences in line (Buchheit M and al., 2010), and in this respect, the level of performance demands during change-of-direction sprint sequences imperatively depends on the angle used.

The results of our study are also in line with those achieved by Dellal A, (2008) in a comparison of 10s-10s, 15s-15s and 30s-30s intermittent effort sessions in line and shuttle performed at 105%, 110%, and 115% of MAS. What's more, during the 3 min post-exercise period, [La] continues to increase in intermittent shuttle exercise sessions. Several authors (Taoutaou Z and al., 1996; Basset D.R and al., 1991 ; Van Praagh E and al., 1989 in Duché P and al., 2001 ; Dupont G and al, 2003) have already reported that [La] peaks around 3 min after exercise, whereas in intermittent online exercise sessions, [La] decreases, implying that lactate oxidation is greater than its production (Bisciotti G.N and al., 2003; Millet A, 2016). A portion in equilibrium with pyruvate is oxidized in the mitochondria (Brooks Sandal., 1999, Gladden, 2000), and another portion is oxidized by the myocardium (Reiss D and Prêvost P, 2013), which is rich in Lacticodehydrogenase (LDH) isoenzyme H (Coulmy N and al., 2002), in which case we infer the high demand on aerobic metabolism during intermittent online effort.

5. Conclusion

In the present study, we tried to explore one of the physiological adaptations during a 10s-20s intermittent effort at high intensity, and on the other hand, to shed light on the physiological impact of changes of direction during a shuttle effort, via the comparison of two types of intermittent effort: one protocol in line, and the other in shuttle with a variable number of changes of direction, and different intensities. Highlighting the physiological repercussions of changes of direction, deceleration and re-acceleration during high-intensity intermittent shuttle effort is of great interest in quantifying intermittent training, bearing in mind that quantifying training load is a recurring issue in team sports in order to improve athlete monitoring.

In the first part of our study, we found that intermittent shuttle training had a different effect on athlete performance than intermittent line training, and that blocking, acceleration and deceleration during the shuttle running protocol significantly increased lactatemia.

Generally speaking, the difference in impact between intermittent effort in line and in shuttle is due, on the one hand, to the greater solicitation of the peripheral component by changes in direction, and on the other hand during intermittent effort sessions in shuttle, despite the fact that the distances the subjects have to cover are mathematically calibrated with beeps, so that each subject runs at a speed equivalent to 100% and 110% of his or her MAS, we found that the subjects reached running speeds at the end of the acceleration phase that were higher (± 1. 5 km/h) than those calibrated in the effort session, given that they had to make up for the delay accumulated at each deceleration and stoppage.

In the second part of our study, where we highlighted the physiological impact of the variability in the number of changes of direction during intermittent shuttle effort, we compared the physiological rethinking and lactatemia of two intermittent shuttle effort protocols, 10s-20s and at 100% and 110% of MAS, with a variable number of changes of direction, at a rate of one block every 3 sec in the first protocol and 5 sec in the second, the results showed significant differences in all intermittent effort sessions with the exception of the 10s-20s session at 110%, it seems that 9 block differences between these two protocols had no significant effect unlike the other sessions where the difference in the number of blocks between the two protocols ≥ 18 blocks,

In this respect, for a rational and harmonious quantification of intermittent effort, the effect of deceleration, blocking and re-acceleration during shuttle effort on the athlete's performance should be taken into consideration.

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