ACTIVE RECOVERY DURING GYMNASTICS SESSION

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Introduction

Coaches pursue varying training objectives based on the particular period of training. Gymnasts, much like sprinters, perform in both aerobic and anaerobic conditions (Jemni, 2000; Sands, 1998). During intense sessions, gymnasts are asked to perform routines while fatigued. They are often asked to find the best compromise among technical effectiveness, safety, and high intensity effort. Gymnasts seldom exceed 16 min of real effort per 2 hours during such training session. How can we improve training volume without inducing fatigue? Fatigue in gymnastics is more than a simple physiological problem. Fatigue-related falls in gymnastics often lead to injury (Kolt and Kirkby, 1999; Sands, 2000a; Tesch, 1980; Tesch et al., 1978).

The effect of 2 kinds of recovery was examined during gymnastics practice (Jemni 2000b). The purpose of this study was to compare the effects of combined and passive recovery between the six men's gymnastic events on BL concentration and performance. By comparing the recovery methods during gymnastic sessions, we hoped to determine guidelines that could assist gymnasts in reducing their BL between competitive events and improve training volume.

Methods

Subjects

Twelve male volunteer gymnasts (21.8 ± 2.4 yr) participated in the study. The Gymnasts competed in national (n = 9) or international levels (French National Team members, n = 3). Descriptive physical information is shown in Table 1. A treadmill test was used to measure gymnasts' $\varsigma O_{2\ max}$ in a secondary study (protocol published by Toraa and Friemel, 2000). Individual anaerobic thresholds (OBLA) (Sjödin and Jacobs, 1981) and corresponding heart rates (HRs) were determined.

Table 1: Physiologic characteristics of the gymnasts

	Age year	B. mass kg	Height Cm	B. fat (%) 4 skinfolds	$\varsigma O_{2\ max}$ ml.kg^{-1}.min^{-1}	HR at OBLA b.min^{-1}
Mean (SD)	21.8 (2.4)	67.49 (7.95)	168.21 (5.96)	10.29 (1.53)	48.30 (4.33)	168,42 (4,03)

OBLA: Onset of Blood Lactate Accumulation (Sjödin and Jacobs, 1981)

Protocol

The tests involved simulations of gymnastics competitions as described in an earlier study (Jemni et al., 2000c) (Figure 1). Two expert national judges judged each gymnast's performance.

Each of the six event performances (routines) was separated by 10 min of recovery. Three blood samples (25 *µ*l) were taken from a hyperaemic earlobe: 2, 5 and 10 min after each event. The determination of BL was performed by a micro-enzymatic method with a Microzym L-analyzer.

The HRs of the gymnasts were continuously monitored by a Bauman and Haldi Sport-tester BHL 6000. Gymnasts were required to warm-up for the next event just after having their blood samples taken at the tenth recovery-minute (3 min specific warm up).

Each gymnast performed two recovery protocols. Protocols were randomized so that during a given session gymnasts performed passive or combined recovery as follows:

- Rest protocol: During each 10 min recovery period of the competition session, gymnasts rested in a sitting position.

- Combined protocol: Gymnasts rested during the first 5 min of the recovery period and then performed 5 min of self-selected active recovery immediately following the 5th min blood sample. The gymnasts typically performed light running separated by handstands, single somersault movements and swings to handstand on the parallel bars. HR was used to monitor and control activity during recovery periods. Gymnasts were instructed to maintain a modestly high HR value (approximately 145 b.min^{-1}), but not to exceed their individual anaerobic threshold values (170 ± 8 b.min^{-1}) that were determined earlier (Stamford et al., 1981; Weltman et al., 1979).

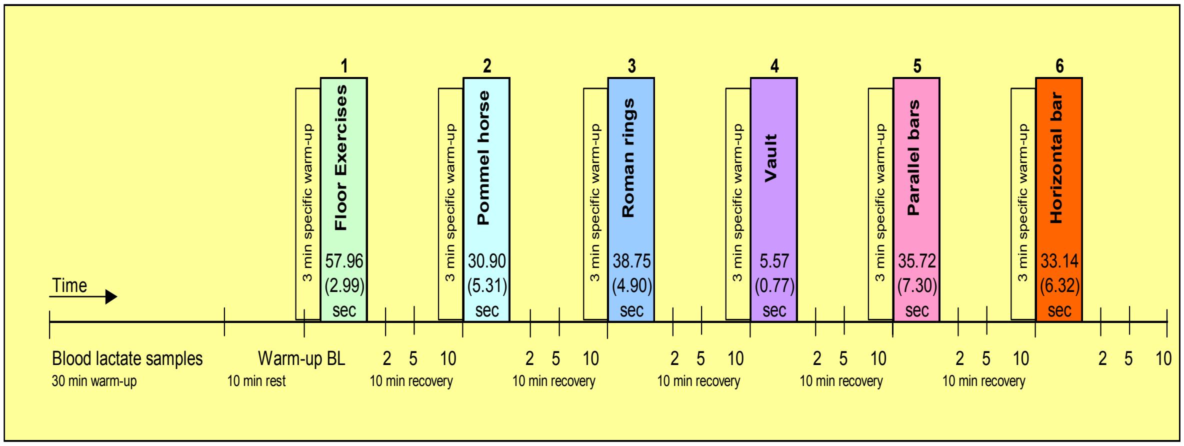


Figure 1: protocol session

Results and Discussion

Blood lactate

Blood lactate information is shown in Figures 2 and 3. Considerable variability was observed among individual BL_{max} values (from 2.21 mmol.1^{-1} at the vault event to 11.64 mmol.1^{-1} at the floor exercise event).

Mean BL_{max} accumulation across all six events during the combined recovery protocol was higher, but not statistically different ($p > .05$), than that of the rest protocol (5.48 ± 1.91 vs 3.79 ± 1.09 mmol.1^{-1} respectively).

BL_{max} values varied between events during the same protocol. The highest event value of the rest recovery protocol was floor exercise (Figure 2) which was significantly higher than the other event averages ($p < 0.5$). The highest BL_{max} event value observed during the combined recovery protocol was the still rings (Figure 3). The vaulting BL_{max} value was significantly lower than the other events during both protocols ($p < .05$).

Higher levels of lactate may be indicative of higher energy output and increased intensity of performance, not simply an increased fatigue stimulus (Bar-Or et al., 1980; Olbrecht, 2000). High performance is correlated to high blood and muscular lactate value during intense anaerobic exercises. Indeed, lactate production depends on age, diet, training characteristics, intensity of activities, and level of fitness (Gaesser and Poole, 1988; Gaul et al., 1995; Tolfrey and Armstrong, 1995; Yoshida, 1986). The fact that better performances result in higher BL concentrations may mean also that the athletes are simply using more of their anaerobic fitness and thus producing higher forces as reflected in their higher BL concentrations.

BL_{max} values of the different events were comparable with those found in the recent literature (Goswami and Gupta, 1998; Lechevalier et al., 1999; Montpetit, 1976, Rodríguez et al. 1999)

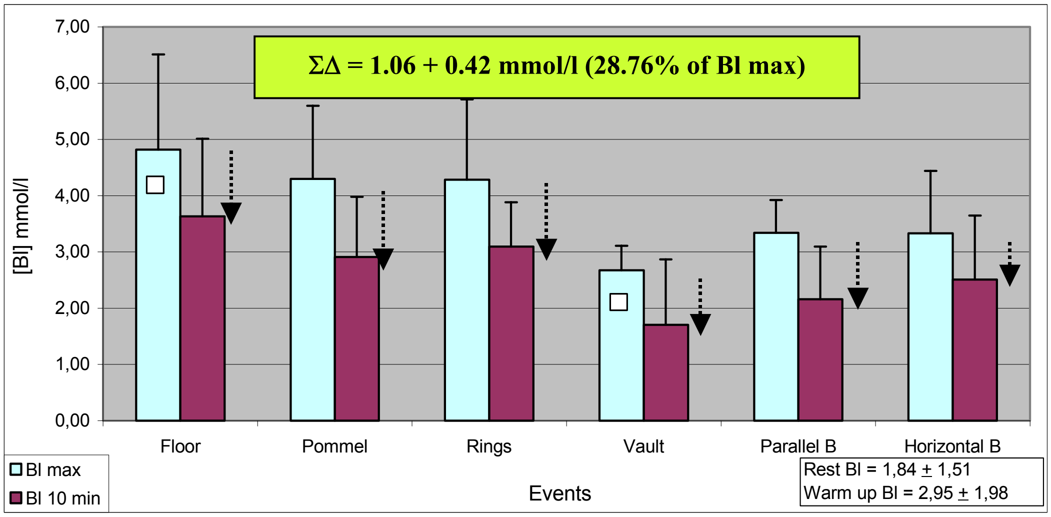
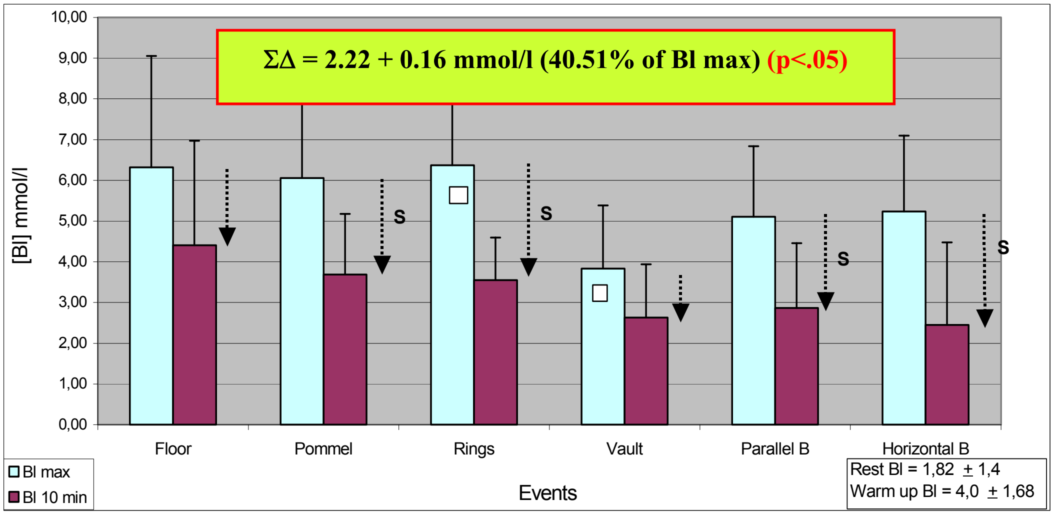


Figure 2: Blood lactate evolution during rest recovery protocol

▼ : (Δ_{BL}) represents the difference in BL values between the peak value and the value obtained after 10 min recovery.
☐: Significantly different if compared with the other event averages (p<.05).

Figure 3: Blood lactate evolution during the combined recovery protocol



▼: (Δ_{BL}) represents the difference in BL values between the peak value and the value obtained after 10 min recovery.

□: Significantly different if compared with the other event averages of the session (p<.05).

S: Significantly different if compared with Δs of the passive recovery protocol (p<.05).

At the end of the 10 min recovery periods, BL values were usually higher than the corresponding rest values before each protocol. Thus, recovery between events was generally not complete. The 10 min recovery BL values were considered the starting values for the next apparatus.

As can be seen in Figures 2 and 3, Δ_{BL} indicates the difference in BL values between the peak value and the value obtained after 10 min recovery. These differences give an indication of the metabolic recovery after each event.

The combined recovery protocol percentages of Δ_{BL} across all events were significantly greater ($p < .05$) than that of the rest protocol (40.51 % vs 22.02 %). Gymnastics events varied with regard to Δ_{BL} as well. BL concentration during the combined protocol was significantly less ($p < .05$) than that of the rest protocol during 4 events: pommel, rings, parallel bars and horizontal bar (Figure 3).

We conclude that moderate activity during the recovery period maintains an adequate blood flow and may improve lactate oxidation and clearance. Lactate can be converted to glucose and protein. However, lactate oxidation in skeletal muscle is the most important mechanism responsible for lactate clearance during exercise (Brooks, 1986; Gaesser and Brooks, 1979; Hermansen et al., 1975; Hermansen and Stensvold, 1972; Hubbard, 1973). The use of isotopic tracers in active and inactive skeletal muscles has demonstrated that lactate is used as a substrate and ultimately converted to CO_2 and H_2O (Corsi et al., 1972; Graham, 1978; Granata et al., 1976; Jorfeldt, 1970; Stanley et al., 1986; Yoshida and Watari, 1993). Lactate, which is produced primarily as a result of type IIb fiber recruitment, is transported to Type I or IIa fibers, where it is oxidized. Indeed, a relationship exists between lactate removal and the percentage of slow twitch fiber, which is in-turn related to the metabolic features of these fibers (Wasserman et al., 1987, 1989). Lactate can be used as a substrate *for ST fibers during low intensity activity because the ST fibers are more dominant in such activities (Andersen, 1975; Bonen and Belcastro, 1976; Bonen et al., 1978; Brooks, 1986).*

Previous studies revealed that exercise recovery at work loads below the anaerobic threshold is more effective, with respect to lactate reduction, than above anaerobic threshold (Stamford et al., 1981; Weltman et al., 1979). The use light workloads for recovery is based on the notion that higher workloads will result in an increased imbalance between the rate of lactate production and clearance. In our study, gymnasts performed 5 min free active recovery during the combined protocol. Exercise intensity was below anaerobic threshold (controlled by heart rate).

Gymnastics performance

The mean performance values of each event and protocol performances are shown in Table 2. Combined recovery protocol performances were significantly improved ($p < .05$) than those of the rest protocol. Total scores were: 42.80 ± 6.82 vs 38.39 ± 7.55, respectively. A statistically significant difference was observed only between floor exercise performances (Table 2). Gymnast performance was significantly correlated with maximal BL only during the combined protocol (Figure 4).
This means: increase in BL_{max} concentration is accompanied by an increase in performance during the combined protocol.

In order to examine the effects of the recovery protocols on performance, the difference between start value and real score attributed at each event (Δ_{score}) was calculated. No statistically significant difference between protocol Δ_{scores} was found. A significant correlation was only found between Δ_{BL} and Δ_{score} of the combined recovery protocol ($r = -0,75$; $p < .05$) (Figure 5). This means: the higher the BL disappearance, the closer the gymnast came to the maximum possible score.

Table 2: Mean values of Gymnastics performances per event and per protocol

Protocol	Floor	Pommel	Rings	Vault	Parallel	Horizontal	Total Score	Δ_{score}
Rest	6,63 (1,33)	5,19 (2,28)	6,33 (1,44)	8,05 (1,03)	6,17 (1,32)	5,99 (1,85)	38,39 (7,55)	1,92 (0,45)
Combined	7,25 (1,15)^{s}	6,56 (1,77)	6,95 (1,57)	8,39 (0,61)	6,81 (1,23)	6,64 (1,43)	42,80 (6.82)^{s}	1,76 (0,54)

s: significantly different (p<0.05) between protocols.

The improvement in total performance score of the combined recovery protocol is considerable as all gymnasts performed the same routines in both protocols. The significant difference between protocol scores, and the significant correlation between Δ_{BL} and Δ_{score}, facilitates the interpretation of the relationship between BL reduction and gymnastic performance. Indeed, Δ_{BL} increased while Δ_{score} decreased. This means, decreased BL concentrations are linked to better performance. Numerous investigations have reported that lactate removal from the blood (i.e., lower concentration) following exercise is of great importance in improving the subsequent performance, particularly when the *exercise is repeated at high intensity (Ahmaïdi et al., 1996, Bogdanis et al., 1994; 1996).*

Heart rate

Mean and SD of heart rates are shown in Table 3. Performances on gymnastic events resulted in high HR values. No statistically significant difference between protocol HRs were found except at the 10th min which showed a higher HR value during the combined protocol.

Mean vault heart rate values were significantly less than those of all other events during both protocols. Differences between apparatuses were shown as horizontal bar resulted in the highest peak HR values during both protocols. Mean HR values during both protocols were 175.78 ± 6.28 b.min^{-1}. After a 10-minute recovery period, HRs were usually greater than their resting values.

Table 3: Mean values (± SD) of peak, average, and after 10 Recovery minute heart rate at each event per protocol in b.min^{-1}

	Peak	Mean	10 min Recovery
Rest protocol M	172.81	162.06	98.74
SD	(12.69)	(7.30)	(2.48)
Combined protocol M	175.96	160.80	135.53
SD	(9.24)	(6.82)	(5.86)[s]

s: significantly different (p < .05) if compared with the other protocol.

The HR values measured during gymnastic routines in ths study were high (Table 3). These values should not be used as a direct indication of effort intensity. It is difficult to interpret HR energetic significance because of the lack of a steady state condition in the performance, and the short duration of the routines. An increase in HRs just before the beginning of each event has been noticed.

Figure 4: Relationship between score (performance) and maximal blood lactate concentration.

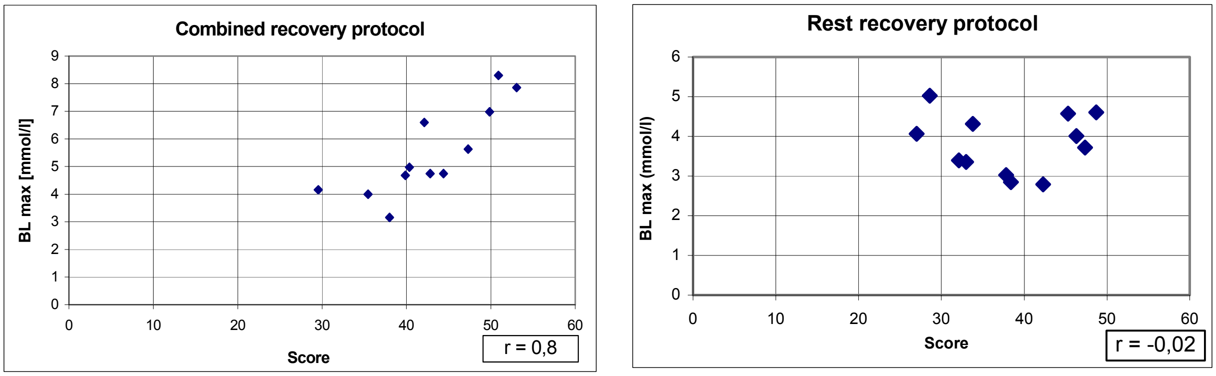
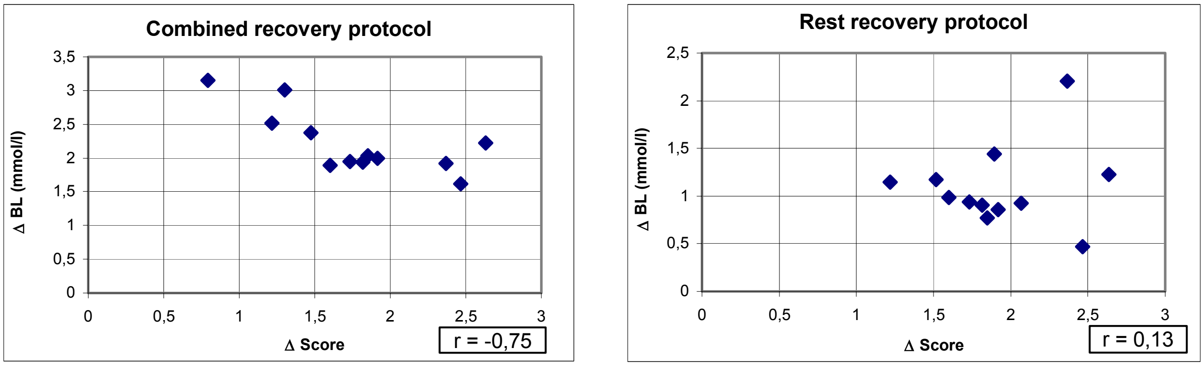


Figure 5: Relationship between Δ_{score} (performance) and Δ_{BL} (BL disappearance)



This HR increase may be partially explained by an increase in catecholamines due to anticipatory responses. However, given the upper body involvement in gymnastics activities, it is possible the high HRs are partially due to the interthoracic pressures associated with maximal upper body efforts and breath holding (Boileau et al., 1984).

Conclusion

During intense gymnastic sessions, gymnasts produce moderately high lactate values. This study shows that a combined recovery inserted between repetitions may be of great importance to the gymnast. Lactate clearance is higher when gymnasts used 5 min rest and 5 min self-selected active recovery with intensity below the lactate threshold. Gymnasts improved their performance when using this kind of recovery. This recovery may be used during the competitive period in which gymnasts usually have to repeat their six events more than twice in one session which is common during training and simulated competitions during training. Because gymnastics shows a relatively high injury rate, and fatigue is often related to injury, this may assist gymnasts in reducing the likelihood of injury.

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