Leg Fidgeting Enhances Blood Lactate Clearance Following Maximal Anaerobic Exercise

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Abstract

Low intensity active recovery such as walking appears to be optimal for the clearance of blood lactate (BLa) concentration following high intensity exercise. However, within a sporting context, competition rules or procedural impracticalities often mean walking is not possible. Leg fidgeting during sitting has been shown to increase leg blood flow, which may impact BLa clearance. The purpose of this study was to determine whether leg fidgeting stimulates BLa clearance following high intensity exercise. Using a randomized crossover design, fifteen (7 female) university athletes performed a 30 s Wingate test followed by 15 min of either passive seated rest, or seated leg fidgeting. BLa, heart rate (HR) and rate of perceived exertion (RPE) were assessed pre, immediately post and post 3, 6, 9, 12, and 15 min. There was a significant (p<0.05) condition x time interaction for BLa. Post hoc analysis found that leg fidgeting caused a significantly greater reduction in BLa compared to sitting at post 6 (fidget 9.9±2.6 vs. sitting 9.9±2.2 mmol·L^{-1}), 9 (9.3±2.3 vs. 9.9± 2.1 mmol·L^{-1}), 12 (8.8±2.3 vs. 9.5±2.2 mmol·L^{-1}) and 15 (7.6±2.1 vs. 8.6± 2.2 mmol·L^{-1}) min respectively. Overall, leg fidgeting improved BLa clearance by 10% more than passive recovery. No significant interactions were found for HR or RPE. Following high intensity exercise, leg fidgeting may be considered a useful alternative to whole body active recovery when walking is not permitted.

Keywords: sitting; blood flow; lactate removal; active recovery

Introduction

It is widely accepted that high concentrations of blood lactate (BLa) is a limiting factor for performance.[1] As such, finding efficient ways to enhance BLa clearance following exercise would be beneficial.[2] Enhancing BLa clearance is particularly important for sports where an athlete is expected to perform repeated bouts of exercise interspersed with short rest periods.[3] For this, active recovery, which controls for energy expenditure has been shown to be the most effective method of improving BLa clearance.[4,5] Specifically, low intensity exercise/activity appears to be the optimal form of recovery following high intensity exercise.[6] However, there is a multitude of Olympic sports where whole-body active recovery between exercise bouts, is either not permitted or not practical. These sports include but are not limited to certain athletics and gymnastics specialties or even team sports at half time or substituted players on the bench. As such, the identification of a novel simple strategy for enhancing BLa clearance whilst in a seated position would likely be of benefit to performance.

Leg fidgeting has previously been shown to augment a range of lower-limb haemodynamic properties, including femoral artery blood flow during periods of prolonged uninterrupted sitting.[7,8] It may be that this increase in leg blood flow may also improve BLa clearance following high intensity exercise. Therefore, the aim of the current study was to determine whether seated leg fidgeting compared to seated passive recovery enhances BLa clearance following high intensity exercise.

Methods

Participants

Fifteen (eight male) undergraduate university athletes (age: 21.1±2.1 years; height: 174.5±10.4 cm; body mass: 75.0±12.4 kg) volunteered to take part in the study. Two participants were excluded from the analysis because they vomited during the passive recovery trial. Following institutional ethical approval which adhered to the standards of the journal and the Declaration of Helsinki,[9] each participant gave written informed consent prior to commencement of any testing. Participants were asked not to conduct strenuous exercise, and to avoid alcohol intake for 24 hours prior to testing. In addition, participants were asked not eat 2 hours prior, or consume caffeine 12 hours prior to testing.

Procedure

Using a randomized cross-over design (https://www.randomizer.org/), participants attended two separate testing visits at the laboratory, each at the same time of day, separated by at least 48 hours but no more than seven days. Upon arrival to the laboratory all participants had their height and mass measured. Following this, resting measures (10-min quiet seated rest) of BLa, rating of perceived exertion (RPE) and heart rate (HR) were determined. Participants then completed a 30s maximal effort (Wingate) on an electronically braked cycle ergometer (Lode Excalibur Sport, Groningen, The Netherlands). Following exercise, BLa, HR and RPE were assessed immediately post, and post 3, 6, 9, 12 and 15 min. During recovery, for the passive recovery trial, participants remained seated and quiet for the 15-min period. For the fidgeting trial, participants were seated, and instructed to perform leg fidgeting for the 15-min period. Leg fidgeting was defined as heel raises (both heels) to a height of 3cm, at a pace of ~120 raises per minute, which was controlled by metronome.

Blood sampling and analysis

Following the cleaning of the first finger using a sterile alcohol wipe, an Accu Check lancing device (Roche Diagnostics GMbH Sandhofer Strasse 116 68305 Mannhelm Germany) was used to pierce the finger to a depth of 1.6mm. Capillary blood (20µL) was collected in a heparin microvette and analysed for determination of BLa concentration using a Biosen C-Line Sport (EKF-diagnostic GmbH, Barleben, Germany) in line with the manufacturer guidelines.

Statistical analysis

Following tests of normality, paired samples *t*-tests were used to determine any differences in peak and total power (W) between the passive and fidgeting trials. A two-way repeated measures ANOVA was used to assess possible interactions and main effects for the dependent variables BLa, RPE and HR. If a significant interaction (Time x Condition) was found, then two separate one-way repeated measures ANOVAs with Bonferroni correction were conducted to determine the differences within conditions (passive and fidget). All data is presented as mean ± SD, mean difference and 95% confidence intervals (95% CI) unless otherwise stated; for effect sizes, Cohens'*d* and Eta^2 were calculated when appropriate. Alpha level of significance was set at 0.05 for all analyses. All statistical analyses were completed using Statistical Package for Social Sciences (SPSS, Version 25, IBM Corporation, USA).

Results

Power

There were no significant or meaningful differences in either peak power (W) [passive = 824 ± 264 vs. fidgeting = 833 ± 285 W, Cohens' d = 0.029] or total work done [passive = 17.2 ± 4.3 vs. fidgeting = 16.9 ± 4.3 KJ; Cohens' d = 0.07], between the passive and fidgeting trials.

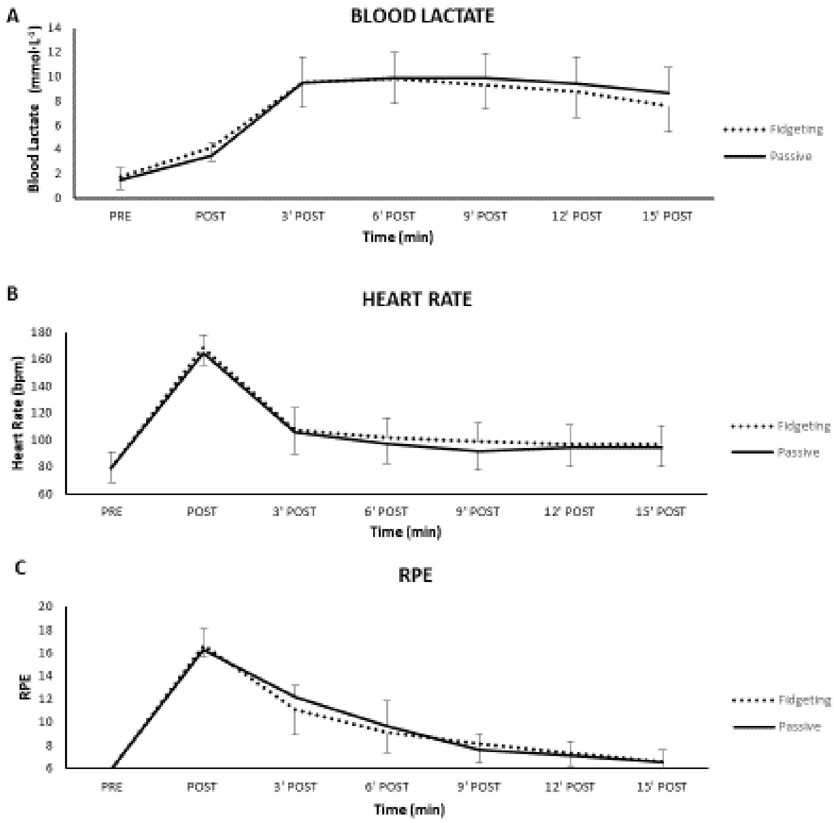
Table 1. Mean ± SD performance, physiological and psychological data for passive and fidgeting exercise and recovery trials

	Fidgeting (N=13)	Passive (N=13)
Peak Power (W)	833 ± 285	824 ± 264
Total Work (W)	17 ± 4	17 ± 4
Blood Lactate (mmo·L^{-1})		
Pre	1.7 ± 0.8	1.5 ± 1.0
0 min post	4.1 ± 1.6*	3.4 ± 1.1*
3 min post	9.6 ± 2.9$^{*,+}$	9.5 ± 2.2$^{*,+}$
6 min post	9.9 ± 2.6$^{*,+,\wedge}$	9.9 ± 2.2$^{*,+,\wedge}$
9 min post	9.3 ± 2.3$^{*,+,\wedge,\neq}$	9.9 ± 2.1$^{*,+,\wedge,\neq}$
12 min post	8.8 ± 2.3$^{*,+,\wedge,\neq,\blacksquare}$	9.5 ± 2.2$^{*,+,\wedge,\neq,\blacksquare}$
15 min post	7.6 ± 2.1$^{*,+,\wedge,\neq,\blacksquare,\bullet}$	8.6 ± 2.2$^{*,+,\wedge,\neq,\blacksquare,\bullet}$
HR (bpm) ╬		
Pre	80 ± 12	80 ± 11
0 min post	168 ± 10	165 ± 11
3 min post	108 ± 17	106 ± 14
6 min post	102 ± 15	97 ± 13
9 min post	99 ± 14	92 ± 16
12 min post	97 ± 14	94 ± 12
15 min post	97 ± 15	93 ± 13
RPE ╬		
Pre	6 ± 0	6 ± 0
0 min post	17 ± 1	16 ± 2
3 min post	11 ± 2	12 ± 1
6 min post	9 ± 2	10 ± 2
9 min post	8 ± 2	8 ± 1
12 min post	7 ± 1	7 ± 1
15 min post	7 ± 1	7 ± 1

HR= heart rate; RPE= rate of perceived exertion; mmol·L^{-1}= millimoles per litre; bpm= beats per minute; W= Watts; min= minutes; *= significant different from pre; $^{+}$= significantly different from 0 min post; $^{\wedge}$= significantly different from 3 min post; $^{\neq}$= significantly different from 6 min post; ▪= significantly different from 9 min post; •= significantly different from 12 min post; ╫= significant time effect

Blood lactate concentration

There was a significant condition x time interaction ($F_{(6,72)}$ = 2.627, p= 0.023, Eta^2= 0.18). Therefore, two separate one-way repeated measures ANOVAs were conducted. There was a significant time effect for both the control ($F_{(6,72)}$= 102.533, p= <0.001, Eta^2= 0.902) and fidgeting groups ($F_{(6,72)}$= 79.188, p <0.001, Eta^2= 0.868). Post hoc Bonferroni revealed significant differences (p<0.05) between all the time points in both conditions. Mean difference and 95% CI revealed that the BLa clearance was greater in the fidgeting compared to the passive condition at 6, 9, 12 and 15 min (Table 1). As a percentage of baseline concentrations, total clearance of BLa over the 15-minute period were 23% and 13% in fidgeting and passive recovery trials respectively. Thus, fidgeting improved BLa clearance by 10% more compared to the passive trial.



RPE= rate of perceived exertion; mmol·L^{-1}= millimoles per litre; bpm= beats per minute; *= significant different from pre; $^{+}$= significantly different from 0 min post; $^{\wedge}$= significantly different from 3 min post; $^{\neq}$= significantly different from 6 min post; ▪= significantly different from 9 min post; •= significantly different from 12 min post; ╫= significant time effect

Figure 1. Mean and SD blood lactate (A), heart rate (B) and rate of perceived exertion (C) responses over time for both passive and fidgeting trials.

Table 2. Mean difference and 95% confidence intervals for blood lactate concentrations during passive and fidgeting recovery periods.

Time	Fidgeting (N=13) Mean difference ($mmol \cdot L^{-1}$)	Fidgeting (N=13) 95% CI	Passive (N=13) Mean difference ($mmol \cdot L^{-1}$)	Passive (N=13) 95% CI
Pre-0 min post	2.405*	-4.197-0.612	1.902*	-3.485-0.319
0-3 min post	5.425*	-7.517-3.984	6.059*	-7.841-4.278
3-6 min post	0.295*	-1.673-1.084	0.438*	-1.574-0.697
6-9 min post	-0.521*	-0.542-1.584	-0.009*	-0.728-0.746
9-12 min post	-0.562*	-0.925-2.048	-0.461*	-0.843-1.765
12-15 min post	-1.2*	0.360-2.040	-0.838*	0.155-1.521

$mmol \cdot L^{-1}$= millimoles per litre; min= minutes, CI= confidence intervals; *= the mean difference is significant different

Heart rate

There was a non-significant interaction of condition x time ($F_{(6,72)}$= 0.732, p= 0.626, Eta^2=0.057). However, there was a significant time ($F_{(6,72)}$= 182.330, p <0.001, Eta^2= 0.938) but not group effect ($F_{(1,12)}$= 1.582, p= 0.232, Eta^2= 0.116).

Rate of perceived exertion

There was a non-significant interaction of condition x time ($F_{(6,72)}$= 1.503, p= 0.190, Eta^2= 0.111) for RPE. However, there was a significant main effect of time ($F_{(6,72)}$= 281.779, p <0.001, Eta^2= 0.959) but not group ($F_{(1,12)}$= 0.051, p= 0.825, Eta^2= 0.004).

Discussion

As far as the authors are aware, this is the first known study to investigate the effects of lower limb fidgeting on post exercise BLa clearance. Lower limb fidgeting over a 15-minute period was found to enhance BLa clearance by 10% more compared to passive rest (control). Whilst this study has some exciting findings, it is important to highlight limitations in order to fully contextualise the results. A repeated exercise bout was not performed and so it is not currently known whether the 10% increase in BLa clearance shown during the fidgeting trial is enough to improve power or total work in subsequent exercise. However, one of the notable strengths of this study is that the results could be extrapolated to a wide variety of sports in which whole body active recovery is not permitted or is difficult to perform.

Previously, studies assessing the hemodynamic responses to uninterrupted prolonged sitting have found that lower limb fidgeting is effective at significantly increasing leg blood flow, shear stress and endothelial function.[7,10] Whilst these studies were assessing vascular health outcomes, the increase in blood flow was likely caused by the muscle pump. An increase in muscle pump activation would likely improve the distribution of BLa to non-exercising muscles, where it could be used as an energy source. Previous research has shown that non-exercising muscle are effective at using BLa as an energy source during recovery.[11] As such, if this supply was increased through leg fidgeting, it may have caused the enhaced clearance seen in Figure 1. However, in the current study this remains speculation, as we did not measure limb blood flow, or BLa consumption in non-exercising muscles.

In the current study, leg fidgeting appears to be superior in enhancing BLa clearance after 6 minutes of heel raises. This delay could be due to the short but maximal nature of the exercise test (30 s Wingate test). With this test, BLa production has previously been shown to continually increase following the test.[12] In addition, it was expected that the improved BLa clearance would have occurred prior to 6 min. It may be that whilst leg fidgeting is enough to stimulate an improved BLa clearance over 15 min, because it is such a low intensity exercise, it has no or little affect on more central responses such as HR (as seen in Table 1), cardiac output, and stroke volume etc. Whilst there is clearly a delay in the improved BLa clearance, this study still has important practical applications. Any leg fidgeting based intervention during a sport would be required to be at least 6 min in duration.

In summary, the present study revealed that leg fidgeting in the seated position for 15 min enhances BLa clearance 10% compared to passive recovery. Sports which require athletes to remain seated in-between exercise periods should consider fidgeting as an alternate to passive rest. Further research is warranted to examine the extent, and the mechanisms by which fidgeting improves subsequent performance.

Practical Applications

Numerous Olympic sporting events in which active recovery or even walking between bouts of high intensity exercise is not permitted; and where passive recovery (normally in sitting position) is the only way to rest, could benefit from this finding. The use of this simple strategy for enhancing lactate clearance may be beneficial to performance is such sports due to a better BLa clearance.

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