Presented by

Laboratory 7 - Exercise Metabolism: Implication of Different Energy Sources
Laboratory presented to
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Introduction

The three energy sources that will be tested in the experiment are ATP-PC, glycolysis (anaerobic), and oxidative (aerobic). The ATP-PC system or Adenosine Triphosphate-Phosphocreatine system is typically used in sporting activities that require a great amount of power for only a short amount of time; for example shotput. The glycolysis system or anaerobic system means without oxygen; this system is typically used for sporting activities that require short bursts of speed and lasts no longer than a minute, for example a 200 metre sprint. The final energy source tested in the experiment is the oxidative or aerobic system meaning with oxygen; this system is used for endurance activities such as a marathon (Artioli et al., 2012).

In a repeated sprint test completed by Bogdanis et al. (1996), it was determined that the aerobic system provided a significant contribution to the energy generation in the second sprint and all subsequent sprints. At the same time the ATP-PC system provided a very important high power generation during the first 10 seconds of the sprint (Bogdanis et al., 1996). These findings are very similar to those determined in a Running-based Anaerobic Sprint Test completed by Milioni et al. (2017). They determined that the contribution of the aerobic system increased significantly throughout the experiment, and that the ATP-PC system was associated with power-performance. The final discoveries from their experiment was that the aerobic pathway played an important role in sprint recovery, the anaerobic pathway decreased sprint performance due to lactic acid build up, and ATP-PC pathway was directly linked to power production (Milioni et al., 2017). ATP-PC system resynthesis following low intensity exercise takes longer than ATP-PC system resynthesis following high-intensity exercise; $t > 15\ s$ vs. $t = 2 - 11\ s$ respectively (Forbes et al., 2008).

The purpose of this experiment is twofold, the first is to determine whether or not 5, 15, or 30 seconds is enough rest to replenish your ATP-PC system during the vertical jump test. The second is to determine if the anaerobic system can provide sufficient energy to sustain the all-out sprint and if 15 seconds rest between sprints is enough time to replenish the anaerobic system. Based on the previously mentioned repeated sprint tests that showed that the aerobic system is the main energy source in a continuous sprint and that the anaerobic system decreased sprint performance it is hypothesized that the anaerobic system will not provide enough energy to sustain the all-out sprint. Based on the study completed by Forbes et al. (2008), it is hypothesized that 5, 15, and 30 seconds will be enough time to replenish the ATP-PC system during the vertical jump test.

Method

Participants

The experiment was completed with 4 female participants; participant A and C were eighteen years of age while participants B and D were seventeen years of age. None of the participants had disabilities pertaining to the lower limbs and none of the participants reported having any cardiovascular problems.

Materials

There were four pieces of equipment used to complete this experiment. A measuring tape that was attached to the wall to measure jump height, 2 cones to indicate the 15 metre sprint distance, a chair so that the experimenters could properly read the jump height, and a stopwatch that was provided to the time keeper. Microsoft Excel was used to create Graph 1 and Graph 2.

Procedure. The first part of the experiment was the jump test experiment as was completed as follows. The measuring tape was attached to the wall in an area where the participant would be able to jump and touch the measuring tape. Participant A was instructed to stand beside the measuring tape and raise their arm so that their initial height could be measured. Once the measurement was taken, Participant A was instructed to complete 24 consecutive jumps in which they touched the measuring when at the apex of their jump so that a jump height could be recorded. Once Participant A completed their trial, Participant B was instructed to complete the same activity, this time taking a 5 second rest period between each jump; the rest time was calculated by the time keeper. Participant C and Participant D completed the same experiment taking a 15 second and 30 second break respectively between jumps. The second part of the experiment was the sprint test experiment and was completed as follows. The two cones were placed 15 metres apart in an open space. Participant B was instructed to sprint from one cone to the other as fast as they could, once arrived at the other cone they took a 15 second break before running back to the other cone. Participant B completed 15 sprints, the sprint times and break times were recorded by the time keeper. Participant C was instructed to complete their 15 all-out sprints continuously with no break between each 15 metre interval. The time was recorded by the time keeper. Participant D was instructed to complete their 15 sprints at at continuous and constant pace with no break between each 15 metre interval. The time was recorded by the time keeper. Once all the participants had completed their sprints they were instructed to walk around the testing area for 5 minutes so that they could recover from the experiment. All data was recorded on a data sheet. Once the experiment was completed the sprint times were used to calculate the total sprint time as well as the average sprint time. The sprint distance was used along with the sprint times to calculated the speed of the participants for every one of the sprints they completed.

Results

Graph 1 shows that Participant A had a constant decrease in the net jump height. It also shows that Participants B, C, and D has fairly consistent net jump heights. Participant A completed 24 consecutive jumps while Participants B, C, and D had a 5, 15, and 30 second break respectively between jumps. It can be seen in Table 1 that Participant A's highest net jump was 13.5 cm and occurred at the beginning of the experiment, the participants lowest net jump height was 6.5 cm and occurred at the end of the experiment. Participant B's highest net jump height was 12 cm and it was seen multiple times throughout the trials as seen in Table 2. As seen in Table 3 Participant C had a very consistent net jump height around 8 and 9 cm. Finally Participant D had a maximum net jump height of 15 cm and remained around a net jump height of 13 cm , as shown in Table 4.

Graph 2 shows that Participant B had a relatively consistent speed throughout the 15 sprints, Participant C had a slowly decreasing speed, and Participant D had a consistent speed throughout the 15 sprints. Table 6 shows that the sprint speed for Participant B was between 3.57 m/s and 4.98 m/s, for Participant C it was between 2.91 m/s and 4.18 m/s, and for Participant D it was between 3.41 m/s and 4.85 m/s. Participant B had a range of sprint speeds of 1.41 m/s, Participant C had a range of 1.27 m/s and Participant D had a range of 1.44 m/s.

Table 1

Net Jump heights of Participant A: No Rest Between Jumps

Trial	Jump Height (inches)	Net Jump Height (inches)
1	38	13.5
2	38	13.5
3	37	12.5
4	38	13.5
5	37	12.5
6	36	11.5
7	35	10.5
8	35	10.5
9	36	11.5
10	35	10.5
11	35	10.5
12	32	7.5
13	33	8.5
14	35	10.5
15	33	8.5
16	33	8.5
17	33	8.5
18	31	6.5
19	32	7.5
20	32	7.5
21	33	8.5
22	33	8.5
23	32	7.5
24	32	7.5

Note: Table 1 shows the jump heights and net jump heights for Participant A.

Table 2

Net Jump Heights of Participant B: 5 second Rest Between Trials

Trial	Jump Height (inches)	Net Jump Height (inches)
1	33	11
2	32	10
3	34	12
4	33	11
5	32.5	10.5
6	32.5	10.5
7	32	10
8	33	11
9	34	12
10	32.5	10.5
11	32.5	10.5
12	33.5	11.5
13	34	12
14	34	12
15	33	11
16	33	11
17	34	12
18	32.5	10.5
19	33.5	11.5
20	34	12
21	34	12
22	31.5	9.5
23	32.5	10.5
24	33	11

Note: Table 2 shows the jump heights and net jump heights for Participant B who took 5 second breaks between each jump.

Table 3

Net Jump Heights of Participant C: 15 second Rest Between Trials

Trial	Jump Height (inches)	Net Jump Height (inches)
1	36	8
2	36.5	8.5
3	37	9
4	37.5	9.5
5	36.5	8.5
6	36	8
7	37	9
8	36.5	8.5
9	37.5	9.5
10	37	9
11	37	9
12	35	7
13	37	9
14	37	9
15	36	8
16	35	7
17	37	9
18	37	9
19	38	10
20	38	10
21	37.5	9.5
22	37	9
23	37	9
24	36.5	8.5

Note: Table 3 shows the jump heights and net jump heights for Participant C who took 15 second breaks between each jump.

Table 4

Net Jump Heights of Participant D: 30 second Rest Between Trials

Trial	Jump Height (inches)	Net Jump Height (inches)
1	33	12
2	33.5	12.5
3	33.5	12.5
4	34	13
5	34.5	13.5
6	33.5	12.5
7	34.5	13.5
8	34	13
9	33.5	12.5
10	34.5	13.5
11	34	13
12	35	14
13	35	15
14	34.5	13.5
15	34	13
16	35	14
17	34.5	13.5
18	33.5	12.5
19	34	13
20	35	14
21	34.5	13.5
22	33	12
23	33.5	12.5
24	34	13

Note: Table 4 shows the jump heights and net jump heights for Participant D who took 30 second breaks between each jump.

Table 5

15 metre Sprints with Varying Pace and Rest Period

Trial	Participant B, time (s)	Participant C, time (s)	Participant D, time (s)
1	4.20	3.92	3.47
2	3.25	3.90	3.10
3	3.40	4.17	3.50
4	3.02	3.70	3.84
5	3.42	3.59	3.90
6	3.69	3.80	3.92
7	3.01	3.96	3.94
8	3.50	3.90	4.05
9	3.85	4.56	3.76
10	3.48	4.98	3.93
11	3.66	4.16	4.09
12	3.74	4.90	3.09
13	3.47	4.98	4.50
14	3.85	5.10	4.36
15	3.74	5.15	4.40
Total Time	53.28	64.77	57.85
Average Time	3.12	4.32	3.86

Note: Table 5 shows the sprint times for Participants B, C, and D. Participant B completed the 15 sprints with a 15 second break between each sprint. Participant C completed the 15 sprints continuously at an all-out pace. Participant D completed the 15 sprints continuously at a constant pace.

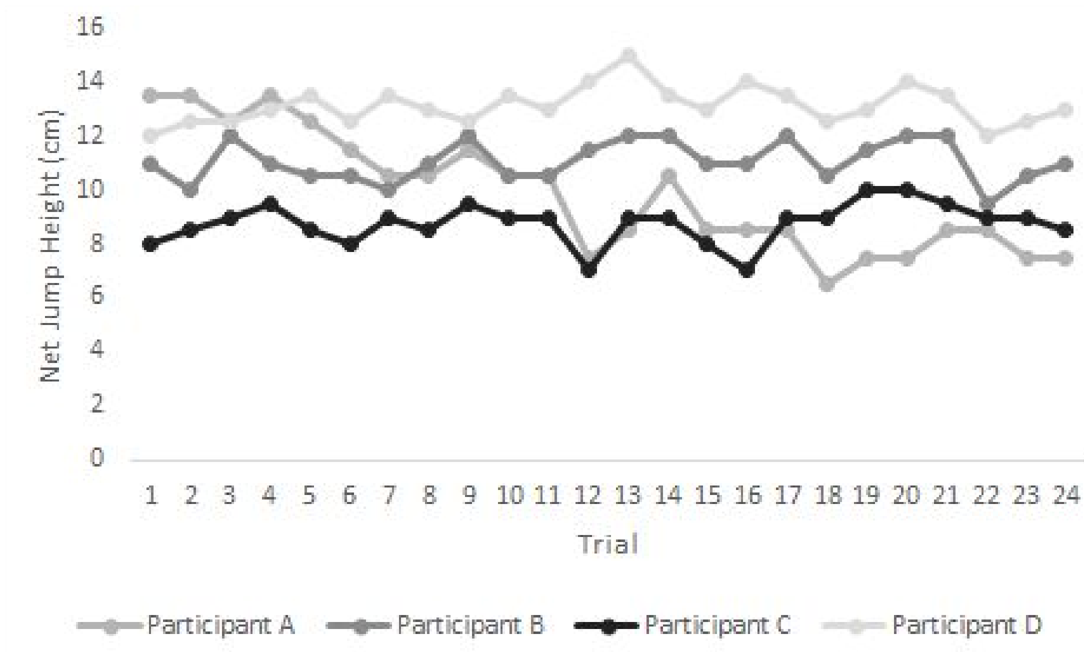
Table 6

Participant Speeds

Trial	Participant B, speed (m/s)	Participant C, speed (m/s)	Participant D, speed (m/s)
1	3.57	3.82	4.32
2	4.61	3.85	4.84
3	4.41	3.59	4.28
4	4.97	4.05	3.91
5	4.38	4.18	3.85
6	4.07	3.95	3.83
7	4.98	3.78	3.81
8	4.29	3.85	3.70
9	3.89	3.30	3.98
10	4.31	3.01	3.82
11	4.10	3.61	3.67
12	4.01	3.06	4.85
13	4.32	3.01	3.33
14	3.90	2.94	3.44
15	4.01	2.91	3.41

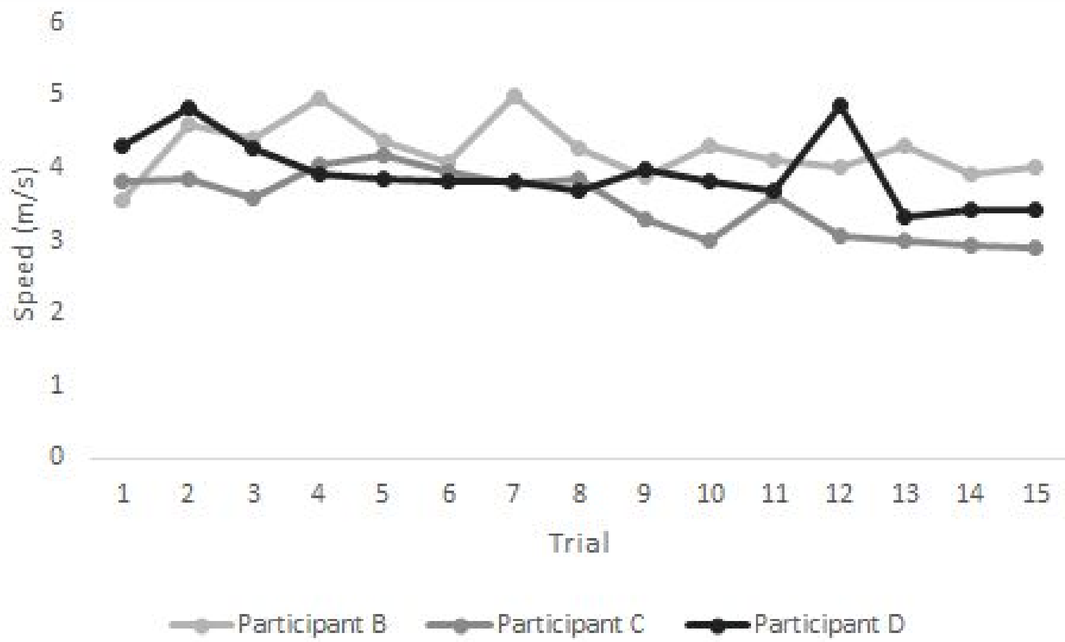
Note: Table 6 shows the sprint speed for Participants B, C, and D.

Graph 1



Note: Net Jump Heights for Participants A, B, C, and D when performing 24 jumps. Graph 1 shows the net jump height (cm) for all 4 participants. Participant A completed 24 consecutive jumps, Participant B completed 24 jumps with a 5 second break between jumps, Participant C completed 24 jumps with a 15 second break between jumps and Participant D completed 24 jumps with a 30 second break between jumps. The greatest net jump height was 15 cm (Participant D) and the lowest net jump height was 7 cm (Participant C)

Graph 2



Note: Sprint speed for Participants B, C, and D. Graph 2 shows the sprint speeds (m/s) for 3 participants. Participant B completed 15 sprints with a 15 second break between sprints, Participant C completed 15 consecutive sprints at an all out pace, and Participant D completed 15 consecutive sprints at a consistent pace.

Discussion

The purpose of this experiment was to test the hypothesis that the anaerobic system would not be able to support the energy expenditures of the all-out sprint, and that 5, 15, and 30 second breaks will be enough time to replenish the ATP-PC system. The results obtained supported the hypothesis; the anaerobic system was not capable of supporting the energy expenditures of Participant C as seen by the fact that their sprint speeds slowly decreased throughout each consecutive sprint (Graph 2). The second part of the hypothesis was also confirmed and can be shown by Graph 1; the net jump heights of Participants B, C, and D remained fairly consistent throughout the trials indicating that the rest period was enough time for the ATP-PC system to replenish.

In Participant A the net jump height decreases consistently over the course of the 24 jumps; this is expected because there is not enough time for the ATP-PC system to regenerate, thus the anaerobic system comes into play and builds up lactic acid which decreases performance (Milioni et al., 2017). In participants B, C, and D the jump heights remain consistent (Graph 1), this is due to the fact that the energy systems have full time to replenish (Forbes et al., 2008). According to the results obtained it can be inferred that a 5 second break is enough time to replenish the immediate energy system within the context of the experiment, due to the fact that the range of recovery time for high-intensity exercise is $t = 2 - 11s$ (Forbes et al., 2008).

Based on Graph 2 it clearly shown that Participant B's time and speed remained fairly constant with slight increases in time in sprint 4 and 7. Participant C who completed 24 all-out consecutive sprints had a consistently increasing time over the course of the trials; in trial 11 Participant C had a slightly faster time. Participant D had a very slight increase in time over the course of the trials due to the fact that they were sick on the day of the experiment, overall their times were fairly consistent. Based on Table 5 the average times for Participant B, C, and D were 3.12 s, 4.32 s, and 3.86 s respectively. Participant C had the highest average time and it correlates with the hypothesis because the anaerobic system is being depleted and there is a buildup of lactic acid which decreases performance (Milioni et al., 2017). Participant B had the fastest average time due to the fact that there was enough recovery time to regenerate the system. Participant D's average time was between the extremes because Participant D was mainly using their aerobic system. Participant C would only benefit from rest between trials if they were given a minimum of 45 minutes rest, as shown in Figure 1 this is the minimal amount of time needed for the body to return a basal state with no lactic acid buildup. Given any less time to recover they would be starting the sprint with lactic acid in their system and the rest time they had been given would not have much of an effect (Goodwin et al., 2007). If the times from all trials were added together Participant B would have completed the total first; as seen in Table 5 Participant B had a total time of 53.28 s, Participant C had a total time of 64.77 s, and Participant D had a total time of 57.85 s.

Possible sources of error include inaccurate timing methods due to the fact that the times were collected from hand-held stopwatches. When measuring sprint times a high degree of precision is needed and electronic timing should be used (Hetzler, Stickley, Lundquist, & Kimura, 2008). Future experiments should be completed with electronic timing gates to minimize error and ensure that the results are accurate. Another source of error is that there was not a sufficient amount of time for the experimenters to properly record the jump height because of the natural speed of a jump. For future experiments, a camera should be used to capture the jump height so that the accuracy of the results can increase.

Conclusion

The results of the experiment supported the hypothesis that the anaerobic system would not be capable of supporting the entirety of the all-out continuous sprint and that a 5, 15, or 30 second break is enough time to replenish the ATP-PC system during the vertical jump test. In the sprint test Participants B and D had fairly consistent times, while Participant C had a consistent increase in time over the course of the 15 trials due to the lactic acid buildup (Table 5 and Graph 2). In the vertical jump test Participant A had decreasing net jump heights due to the lack of time allowed for the replenishing of the system. Participants B, C, and D had sufficient amount of time to recover and maintain consistent net jump heights (Graph 1). It is concluded that a 5 second break between jumps is the minimum amount of break time required to regenerate the system. It has been determined that electronic timing should be used (Hetzler, Stickley, Lundquist, & Kimura, 2008). Future experiments should be completed with the use of electronic timing gates, and a camera to observe jump heights. These same tests could be completed to compare the use and recovery time of these systems between males and females, as well as the effects that different stress factors can have on the systems (ex. heat, experiments conditions).

References

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Appendix:

$speed\ (m/s) = \frac{distance\ (m)}{time\ (s)}$

$speed\ (m/s) = \frac{15\ m}{3.40\ s}$

$speed\ (m/s) = 4.41\ m/s$

$Total\ time\ (s) = sum\ of\ all\ times\ (s)$

$Total\ time\ (s) = 4.2 + 3.25 + 3.4 + 3.02 + 3.42 + 3.69 + 3.01 + 3.5 + 3.85 + 3.48 + 3.66 + 3.74 + 3.47 + 3.85 + 3.74$

$Total\ time\ (s) = 53.28\ s$

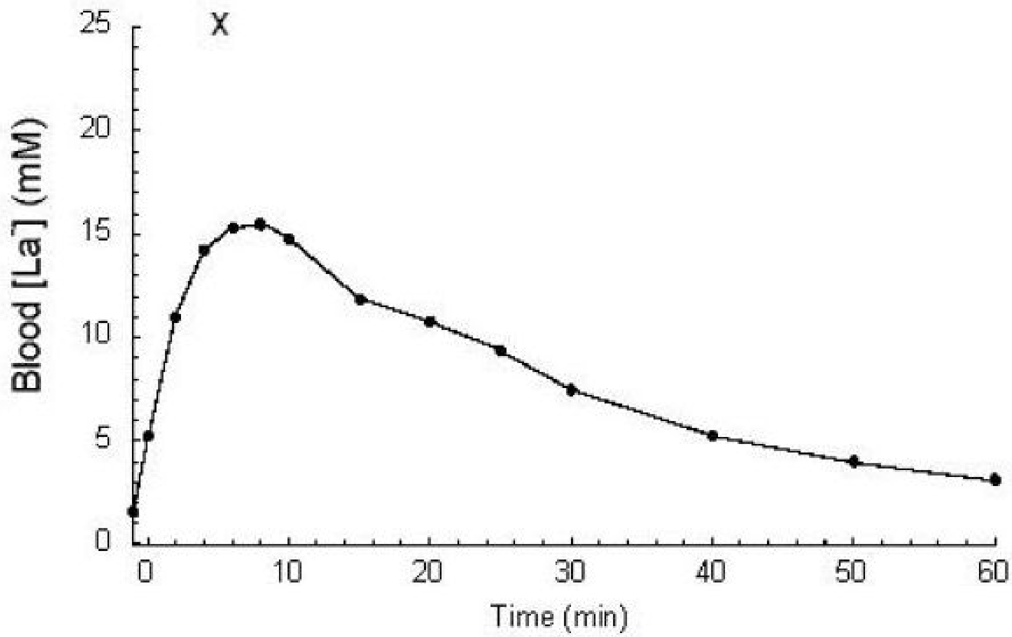
$Average\ time\ (s) = \frac{sum\ of\ all\ times\ (s)}{15}$

$Average\ time\ (s) = \frac{4.2+3.25+3.4+3.02+3.42+3.69+3.01+3.5+3.85+3.48+3.66+3.74+3.47+8.85+3.74}{15}$

$Average\ time\ (s) = \frac{46.84}{15}$

$Average\ time\ (s) = 3.12\ s$

Figure 1



Note: Figure 1 shows the time needed to fully drain lactic acid from the body after all-out exercise (Goodwin et al., 2007).