

# Get 'em Moving, But How? Exercise Following Sport Related Concussion

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## Mild Traumatic Brain Injury Symposium

Emily M. Kosderka ABD, ATC, ITAT

Associate Professor of Exercise & Sport Science

Concordia University-Portland, OR



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# Objectives

- **Review** the rationale & recommendations for inclusion of exercise in the management of concussion
- **Examine** the existing research on frequency, intensity, time, type, and timing of exercise
- **Demonstrate** how existing evidence can be translated into clinical practice

# A Paradigm Shift...



<http://www.enaturalawakenings.com/Health-Briefs-Archive/Silence-De-Stresses-the-Brain/>

<https://maymassage.info/thong-tin-can-biet-ve-xe-dap-tap-the-duc-reebok-z7-re1-11710/>

## Consensus statement on concussion in sport—the 5<sup>th</sup> international conference on concussion in sport held in Berlin, October 2016

Paul McCrory,<sup>1</sup> Willem Meeuwisse,<sup>2</sup> Jiří Dvorak,<sup>3,4</sup> Mark Aubry,<sup>5</sup> Julian Bailes,<sup>6</sup> Steven Broglio,<sup>7</sup> Robert C Cantu,<sup>8</sup> David Cassidy,<sup>9</sup> Ruben J Echemendia,<sup>10,11</sup> Rudy J Castellani,<sup>12</sup> Gavin A Davis,<sup>13,14</sup> Richard Ellenbogen,<sup>15</sup> Carolyn Emery,<sup>16</sup> Lars Engebretsen,<sup>17</sup> Nina Feddermann-Demont,<sup>18,19</sup> Christopher C Giza,<sup>20,21</sup> Kevin M Guskiewicz,<sup>22</sup> Stanley Herring,<sup>23</sup> Grant L Iverson,<sup>24</sup> Karen M Johnston,<sup>25</sup> James Kissick,<sup>26</sup> Jeffrey Kutcher,<sup>27</sup> John J Leddy,<sup>28</sup> David Maddocks,<sup>29</sup> Michael Makdissi,<sup>30,31</sup> Geoff Manley,<sup>32</sup> Michael McCrea,<sup>33</sup> William P Meehan,<sup>34,35</sup> Sinji Nagahiro,<sup>36</sup> Jon Patricios,<sup>37,38</sup> Margot Putukian,<sup>39</sup> Kathryn J Schneider,<sup>40</sup> Allen Sills,<sup>41,42</sup> Charles H Tator,<sup>43,44</sup> Michael Turner,<sup>45</sup> Pieter E Vos<sup>46</sup>

- “After a brief period of initial rest (24–48 hours), symptom-limited activity can be begun while staying below a cognitive and physical exacerbation threshold.” (*McCrory et al., 2017*)
- “Future studies should evaluate the optimal timing, mode, duration, intensity, and frequency of treatment during the post-acute time period following concussion.” (*Schneider et al., 2017*)

# Timing—when should patients begin exercising after injury?

- 24-48 hours of rest recommended
- Early studies investigated exercise intervention with **mostly PCS** patients & demonstrated it to be **safe** (Gagnon et al. 2009; Leddy et al., 2010, Baker et al., 2012)
- More recent studies have been moving the timeline back **closer to the date of injury**
- **Subacute** or postacute phase
- Determine **status** of the patient

Author (year)	Time following injury
Gagnon et al., 2009	4-18 weeks
Leddy et al., 2010	6-40 weeks
Baker et al., 2012	8-40 weeks
Maerlender et al., 2015	“recently concussed”
Lawrence et al., 2018	1-10 days
Micay et al., 2018	6 days
Leddy et al., 2019	<10 days (mean 5 days)
Popovich et al., 2019	<16 days vs >16 days

# Mode—what type of exercise should they perform?

- **Aerobic**
- Relatively universal using either a **stationary bike or treadmill**
- Popovich et al., (2019) include med balls, **agility drills, & sport specific exercises**
- Resistance exercise (weight lifting) **not recommended** (Worts et al., 2019)

Sports Medicine (2019) 49:683–706  
<https://doi.org/10.1007/s40279-019-01065-1>

## REVIEW ARTICLE



### A Physiologically Based Approach to Prescribing Exercise Following a Sport-Related Concussion

Phillip R. Worts<sup>1,2,3</sup> · Scott O. Burkhardt<sup>4,5</sup> · Jeong-Su Kim<sup>2,3,6</sup>



# Intensity-At what intensity level should patients exercise?

Intensity	Authors
Stationary bike; elliptical; running; med balls, agility drills, & sport specific exercises (HR & RPE)	Popovich et al., (2019)
Perceived exertion of “mild” to “moderate” on Borg scale	Maerlender et al., (2015)
Borg RPE of 11 for 2-5 minutes; increase RPE 1 every 5 min	Kurowski et al., (2016)
15 min @ 100-120 bpm; 30 min @ 100-120 bpm; 30 min @ 140; 1 min max sprint every 5 min for 30 min	Lawrence et al., (2018)
60% APMHR	Dobney et al., (2018)
80% of HR achieved on a sub-maximal treadmill test (Buffalo Protocol)	Leddy et al., (2010); Baker et al., (2012); Clausen et al., (2015); Polak et al., (2015); Cordingly et al., (2016); Leddy et al., (2019)

**Borg's Rating of Perceived Exertion (RPE) Scale**

Perceived Exertion Rating	Description of Exertion
6	No exertion. Sitting & resting
7	Extremely light
8	
9	Very light
10	
11	Light
12	
13	Somewhat hard
14	
15	Hard
16	
17	Very hard
18	
19	Extremely hard
20	Maximal exertion

# The **Buffalo** Protocol

- Assesses exercise intolerance in concussed individuals
- The **BCTT** has been demonstrated to be **valid and reliable** (Leddy et al., 2011)
- The **BCTT** has been shown to be **safe** for use both in PCS as well as acute concussion (Cordingly et al., 2016; Leddy et al., 2017)
- Provides a **symptom-limited threshold, individualized** framework for exercise prescription
- May be **prognostic** of time to recovery (Haider et al., 2019)



<http://concussion.ubmd.com/>

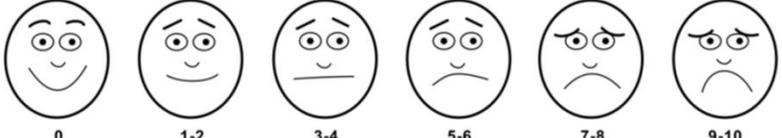


<http://www.smbs.buffalo.edu/ortho/unknown%209-10/answers.html>

# Buffalo Concussion Treadmill Test (BCTT)

- Set treadmill at a speed of **3.2-3.6 mph**
- After **one minute** at this pace, treadmill **incline is increased to 1 degree**.
- Patient is asked to **rate RPE** and **symptom severity**. Subjective scores and **heart rate (bpm)** are **recorded**.
- This procedure is repeated each minute, with ratings and heart rate being recorded, and treadmill **increasing in incline at a rate of 1 degree/minute**.
- **1 point** given for each increase in a symptom or appearance of a **new symptom**

**Rate Your Overall Condition**



0	1-2	3-4	5-6	7-8	9-10
Feel terrific, no symptoms	Feel some symptoms but quite tolerable	Symptoms a little worse	Symptoms much worse	Feeling quite symptomatic	Feel terrible, worst I ever felt

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6	No exertion. Sitting & resting
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13	Somewhat hard
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16	
17	Very hard
18	
19	Extremely hard
20	Maximal exertion

# Stopping Criteria

- Maximum exertion (**RPE score of  $\geq 17-19$** ) is reported
- Symptom exacerbation that causes significant increase in pain or symptom severity  **$\geq 3$  points** over the pre-test overall symptom score on the 1-10 point VAS;
- Clinician notes a **rapid progression** of complaints (ex. headache to searing focal pain) between symptom reports, patient appears faint or unsteady, or determines that continuing the test constitutes significant health risk for the participant,
- **Patient reports** an inability to continue the test safely

# The Buffalo Concussion Bike Test (BCBT)

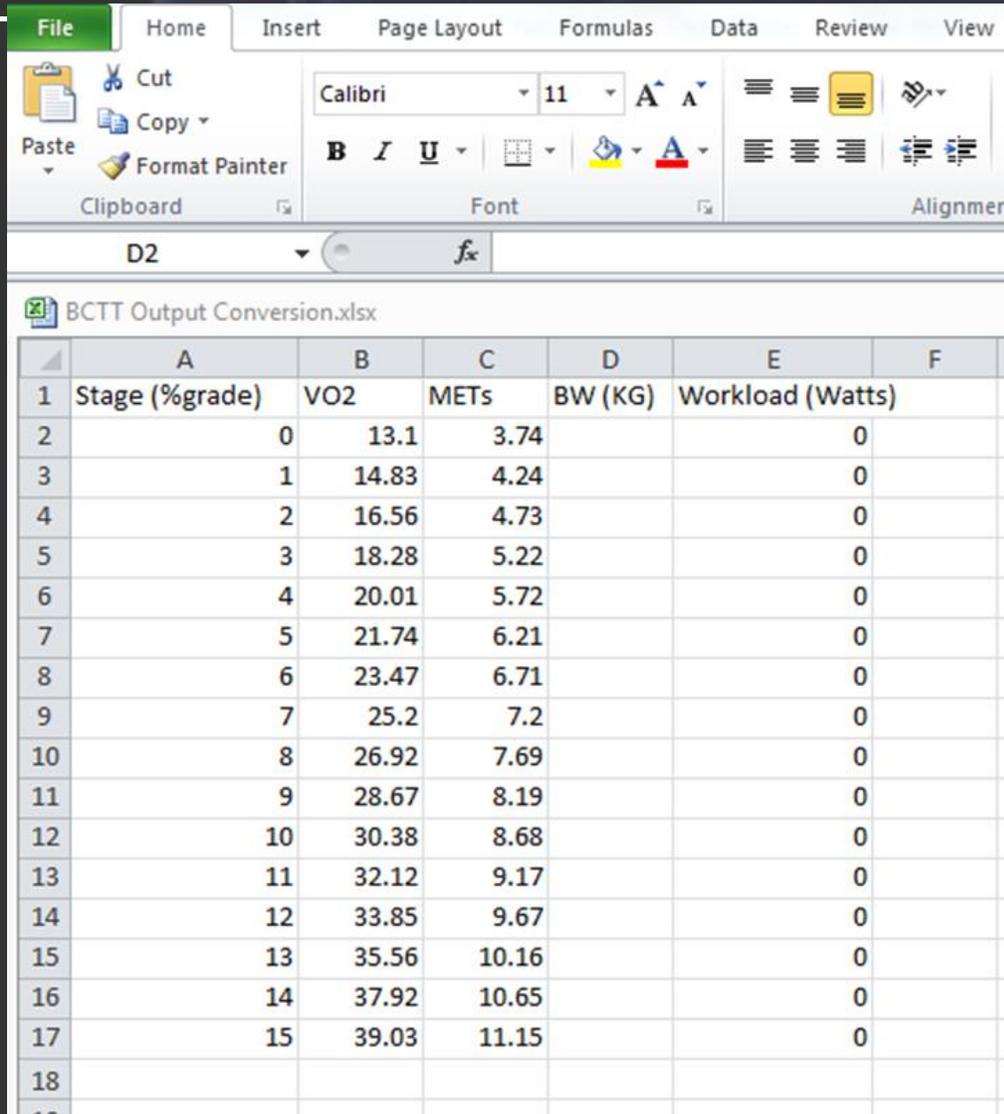
## The Buffalo Concussion Bike Test for Concussion Assessment in Adolescents

Mohammad N. Haider, MD,<sup>\*,††</sup> Samantha L. Johnson, MSc,<sup>†</sup> Rebekah Mannix, MD,<sup>§</sup>  
Alexander J. Macfarlane, BSc,<sup>¶</sup> Dylan Constantino, BSc,<sup>¶</sup> Blair D. Johnson, PhD,<sup>¶</sup>  
Barry Willer, PhD,<sup>¶</sup> and John Leddy, MD<sup>†</sup>



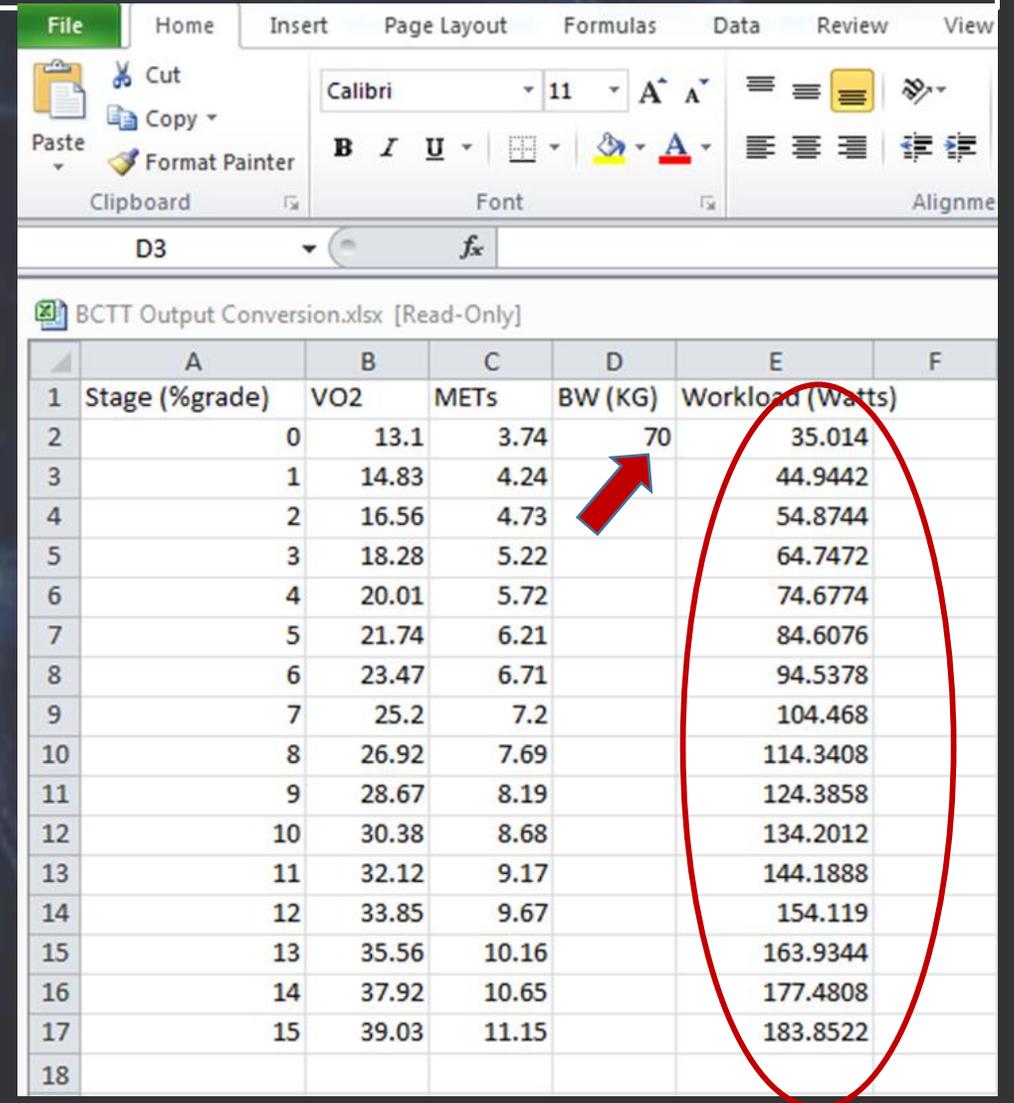
# BCBT power output conversion spreadsheet

(convert from pounds to kilograms:  $bw \text{ (lbs)} \div 2.2 \text{ kg}$ )



This screenshot shows the Excel interface with the spreadsheet 'BCTT Output Conversion.xlsx' open. The active cell is D2. The spreadsheet contains a table with the following data:

	A	B	C	D	E	F
1	Stage (%grade)	VO2	METs	BW (KG)	Workload (Watts)	
2		0	13.1	3.74		0
3		1	14.83	4.24		0
4		2	16.56	4.73		0
5		3	18.28	5.22		0
6		4	20.01	5.72		0
7		5	21.74	6.21		0
8		6	23.47	6.71		0
9		7	25.2	7.2		0
10		8	26.92	7.69		0
11		9	28.67	8.19		0
12		10	30.38	8.68		0
13		11	32.12	9.17		0
14		12	33.85	9.67		0
15		13	35.56	10.16		0
16		14	37.92	10.65		0
17		15	39.03	11.15		0
18						



This screenshot shows the Excel interface with the spreadsheet 'BCTT Output Conversion.xlsx [Read-Only]' open. The active cell is D3. The spreadsheet contains a table with the following data:

	A	B	C	D	E	F
1	Stage (%grade)	VO2	METs	BW (KG)	Workload (Watts)	
2		0	13.1	3.74	70	35.014
3		1	14.83	4.24		44.9442
4		2	16.56	4.73		54.8744
5		3	18.28	5.22		64.7472
6		4	20.01	5.72		74.6774
7		5	21.74	6.21		84.6076
8		6	23.47	6.71		94.5378
9		7	25.2	7.2		104.468
10		8	26.92	7.69		114.3408
11		9	28.67	8.19		124.3858
12		10	30.38	8.68		134.2012
13		11	32.12	9.17		144.1888
14		12	33.85	9.67		154.119
15		13	35.56	10.16		163.9344
16		14	37.92	10.65		177.4808
17		15	39.03	11.15		183.8522
18						

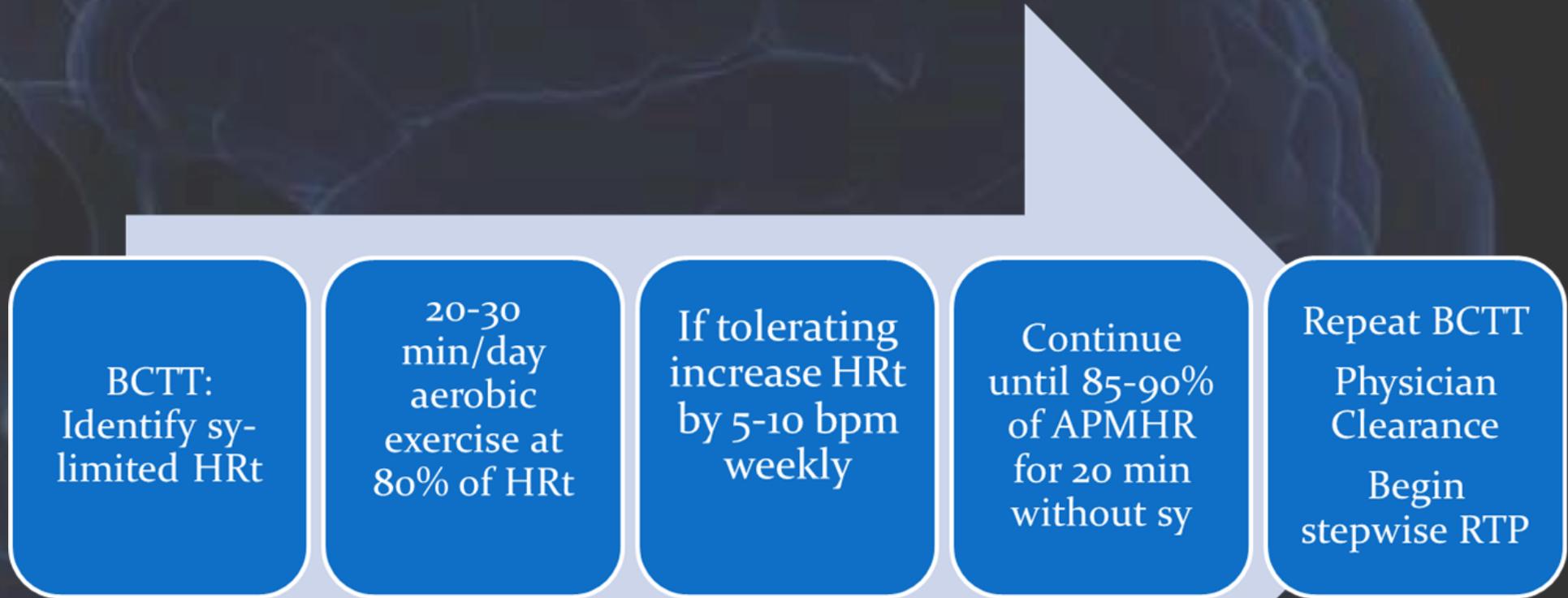


A	B	C	D	E	F
Stage (%grade)	VO2	METs	BW (KG)	Workload (Watts)	
0	13.1	3.74	65	32.513	
1	14.83	4.24		41.7339	
2	16.56	4.73		50.9548	
3	18.28	5.22		60.1224	
4	20.01	5.72		69.3433	
5	21.74	6.21		78.5642	
6	23.47	6.71		87.7851	
7	25.2	7.2		97.006	
8	26.92	7.69		106.1736	
9	28.67	8.19		115.5011	
10	30.38	8.68		124.6154	
11	32.12	9.17		133.8896	
12	33.85	9.67		143.1105	
13	35.56	10.16		152.2248	
14	37.92	10.65		164.8036	
15	39.03	11.15		170.7199	

A	B	C	D	E
Stage (%grade)	VO2	METs	BW (KG)	Workload (Watts)
0	13.1	3.74	81	40.5162
1	14.83	4.24		52.00686
2	16.56	4.73		63.49752
3	18.28	5.22		74.92176
4	20.01	5.72		86.41242
5	21.74	6.21		97.90308
6	23.47	6.71		109.39374
7	25.2	7.2		120.8844
8	26.92	7.69		132.30864
9	28.67	8.19		143.93214
10	30.38	8.68		155.28996
11	32.12	9.17		166.84704
12	33.85	9.67		178.3377
13	35.56	10.16		189.69552
14	37.92	10.65		205.37064
15	39.03	11.15		212.74326

A	B	C	D	E
Stage (%grade)	VO2	METs	BW (KG)	Workload (Watts)
0	13.1	3.74	99	49.5198
1	14.83	4.24		63.56394
2	16.56	4.73		77.60808
3	18.28	5.22		91.57104
4	20.01	5.72		105.61518
5	21.74	6.21		119.65932
6	23.47	6.71		133.70346
7	25.2	7.2		147.7476
8	26.92	7.69		161.71056
9	28.67	8.19		175.91706
10	30.38	8.68		189.79884
11	32.12	9.17		203.92416
12	33.85	9.67		217.9683
13	35.56	10.16		231.85008
14	37.92	10.65		251.00856
15	39.03	11.15		260.01954

# Test – Prescribe- Re-test



BCTT:  
Identify sy-  
limited HRt

20-30  
min/day  
aerobic  
exercise at  
80% of HRt

If tolerating  
increase HRt  
by 5-10 bpm  
weekly

Continue  
until 85-90%  
of APMHR  
for 20 min  
without sy

Repeat BCTT  
Physician  
Clearance  
Begin  
stepwise RTP

**At stage 3 of the  
RTS Strategy**

# Duration & Frequency-How long should patients exercise...and how often?

- Most studies use 20-30 minutes
- Same duration as achieved on the treadmill test (Leddy et al., 2010; Grabowski et al., 2017)
- 15 min; 30 min; sprints for 30 min (Lawrence et al., 2018)
- Individualized/symptom limited 4-50 min (Popovich et al., 2019)
- Frequency 5-7 days per week



rawpixel

<https://www.rawpixel.com/image/378309/premium-photo-image-stopwatch-african-african-descent>

## In Summary...

- **Frequency**: Most studies used daily exercise with at least one rest day per week
- **Intensity**: Most studies used heart rate & prescribed “sub-symptom threshold”; some used Rate of Perceived Exertion (RPE)
- **Type**: All studies used aerobic exercise—most utilizing an exercise bike
- **Time**: Most studies recommended 20-30 minutes
- **Timing**: Most studies were with subjects with prolonged symptomology (PCS); more recent research is moving closer toward the date of injury

## But does it “work”?

- Daily **low intensity, sub-symptom threshold aerobic exercise** has been demonstrated **to be safe during concussion recovery** (*Baker et al., 2012; Cordingly et al., 2016; Maerlender et al., 2016; Leddy et al., 2017; Mychasiuk et al., 2016; Gall et al., 2003; Kurowski et al., 2016*)
- Those who began exercise within 6 days of injury **returned to sport 9 days sooner** than those who waited (mean 26.5 11.2 days vs 35.1 26.5 days;  $P=0.020$ ) (*Popovich et al., 2019*)
- For **each successive day in delay to initiation of aerobic exercise**, individuals had a less favorable recovery trajectory (*Lawrence et al., 2018*)
- Those who exercised recovered approximately **4 days sooner** than those who didn't (*Leddy et al., 2019*)
- No difference in recovery time, but much **improved symptom burden** (*Micay et al., 2018, Howell et al., 2018*)
- **No negative outcomes**

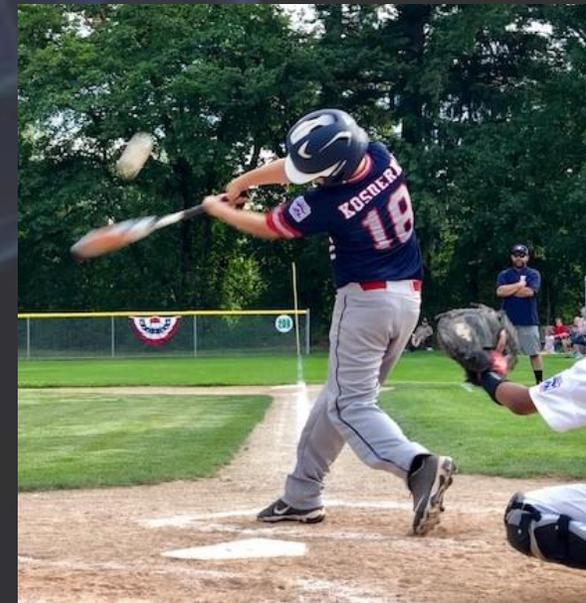


Best Research  
Evidence

Evidence Based  
Practice

Patient  
Opinions &  
Values

Professional/  
Clinical  
Experience



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# Thank You!!



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