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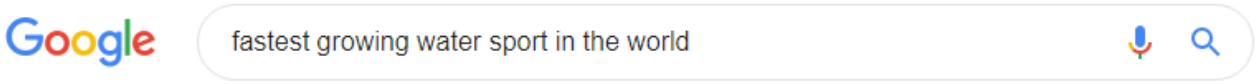
SUP: Does it Stand Up to Science?



If you do the above, The Big G will leave you with no doubts. It is Stand Up Paddleboarding... and by a long way. The stats from the leisure industry, tourism, retail, corporate, fitness "councils" and governing bodies will all reveal the significant and ongoing growth in SUP. It's here to stay and its development will continue in all aspects. In a way SUP has grown quietly and organically from folks plodding around on old windsurf boards, to an early up-take "industry" that may have been seen as niche and eccentric, through to the commercial mainstream along with its product development, different disciplines, and of course professional competition. But one thing has always remained consistently associated with SUP... it is seen as a distinctly healthy lifestyle/hobby choice. It seems to attract good press, it is accessible, eco-friendly, uncomplicated, affordable... it is the floating elixir. The SUP world has done its thing and soaked it all up... it's a sport that doesn't need to be smug and noisy. As if it knows it's healthy.

I am a SUP nut. That puts me in the compromising position of personal bias and potential vested interest for this review. But I am also pathologically sceptical and a bit of a worrier, which are good traits for a reviewer. What provoked my worry gland about SUP is essentially all the good press... is it too good?
What constantly itches my scepticism is a phrase I hear so often. You have just told someone you are into a bit of SUP and they reply, "Oh, that's good for your core isn't it". How do you know, you don't even do it! I have to stop myself from saying. The core thing has a double bubble effect on my "sceptitis". One: I don't really know if SUP is good for core. Two: If it turns out it isn't, do I have to go and tell all the thousands of folks who are thoroughly convinced it is?
Then I stumbled upon a 2017 copy of The Denver Post (long story). In an article within, Melissa Lewis, a fitness trainer who has a master's degree in exercise physiology, and is the operations manager at Rocky Mountain Paddleboard, states you can burn between 300 and 500 calories per hour if you're paddling at a moderate speed. I heard voices in my head, they said, "does it really?", another said "how do you know?". 500 is a fair chunk of calories, I do know that.
Then I went and stumbled again, clumsy. This time it was into a fitness and lifestyle website devoted to SUP. And this is what it said;
"Stand Up paddle boarding is the new IN water sport but it offers a lot benefits. They are good for your body, mind, and whole being. You will be surprised how it can be very beneficial for everyone."
Aside from the use of colloquialism, and confusing me as to whether my body was part of my whole being... these were sweeping claims. But what were these benefits that were so beneficial? I clicked on to reveal the list...

1. Makes you have an outdoor life
2. Helps you maintain your balance
3. Anti-Stress

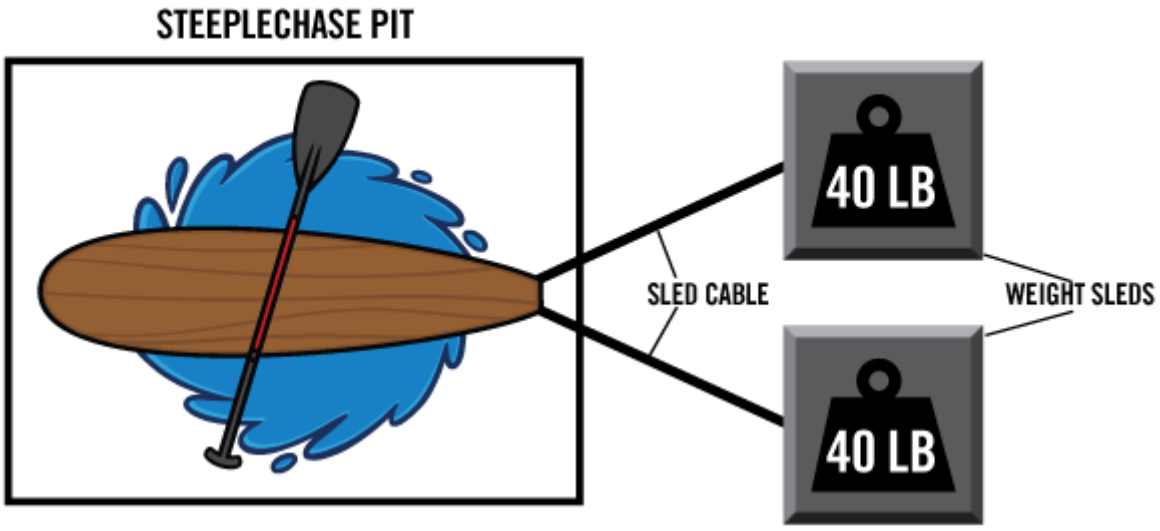
4. It is a whole body workout
5. It is not a high impact sport
6. Makes you lose those unwanted pounds
7. It's good for the heart
8. It is meditative

Each entry on the list was supported with a paragraph of text often containing the phrase "studies show that...". But there were no studies quoted or referenced. I'm a bit pompous though, because the website was essentially great, with lots of practical and free advice on how to get into SUP. The studies thing didn't surprise me, primarily because when looking for research and published articles on SUP, they are few and far between. The "academic" aspect of the evidence base concerning SUP is surprisingly scant considering its growth and popularity. The purpose of this review is to discuss some of the available academic studies... and will allow me to self medicate an over-active worry gland.

Lets start with Core

The American Council on Exercise (ACE) commissioned 3 studies into SUP primarily in 2016.
One was core specific. "Core Muscle Activation During Stand Up Paddleboarding", Porcari et al, University of Wisconsin-la Crosse.
The researchers used a novel way of providing a controlled SUP environment by testing paddlers in the steeplechase pit whilst tethered.

Figure 3
Testing Set-up



They used EMG recording to establish % of Maximum Voluntary Contraction (MVC) within core muscle groups. Previous research has concluded that activity that elicits muscle activity above 45% of %MVC should result in measurable strength improvement. On a Rate of Perceived Exertion scale with a max of 20 they were asked to paddle at perceived rates 11, 13, and 15... so basically three levels of ascending effort, with 15 being a high intensity perceived effort.

Figure 4

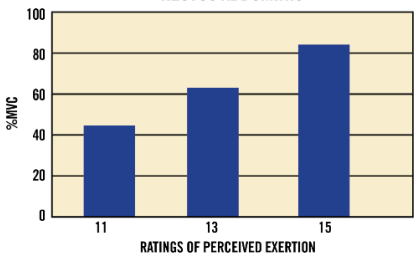


Figure 5

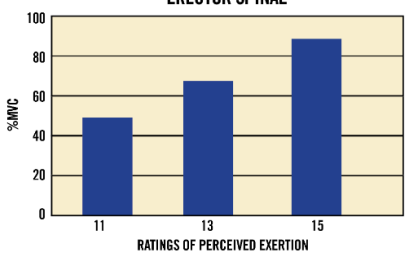
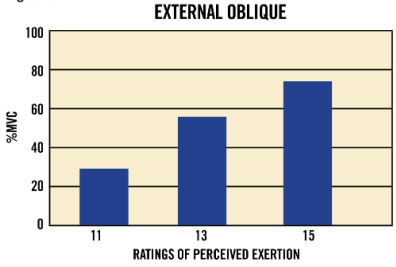


Figure 6



The results showed that rectus abdominus at the front and erector spinae at the back got above the 45% threshold at all levels of effort, and hit above 80% MVC at level 15 effort. External oblique needed an effort of 15 to get it above the 45% threshold. The authors noted that with the external oblique some degree of technique adaptation occurs at higher effort levels (torso rotation), leading to more recruitment.

From my perspective there is strong indication that SUP at higher effort levels provides sufficient stimulus for trunk strengthening... or core training if you like! I was particularly interested in the high level %MVC within erector spinae of the low back. Most folks think abdominals when talking "core", and put the emphasis on abdominal based exercises, but erector spinae is equally important for overall trunk strength. We could also interpret these results as seeing SUP as a useful activity for back strengthening.

What about the 500 calorie claim?

Professor Porcari and his team at University of Wisconsin-LaCrosse also published a paper called, "Physiological Responses to Stand Up Paddleboarding". And they made people do this:

They had designed the first study to investigate VO2 parameters in paddleboarding, and represented some of their energy expenditure data in caloric values. They also tested the participants at the same 3 levels of RPE (11, 13, 15). The caloric values for **30mins** at the perceived exercise level are below:

	RPE 11	RPE 13	RPE 15
male	312	369	517 (1034 per hour)
female	228	282	327 (654 per hour)

It seems the 500 cal an hour claim was easily met and not surprisingly the researchers concluded that SUP "meets industry guidelines for cardio-respiratory endurance training". They are pretty high values, and the researchers commented that level 15 was considered "very vigorous" . Melissa in The Denver Post was quoting 300 - 500 cals for 1 hours moderate paddling. I guess it depends upon your perception of moderate... but doesn't it always? Ultimately Melissa was right, SUP offers a valid alternative for cardio training. There is plenty of energy expenditure data on cycling, running and swimming and one thing to consider would be the time against intensity balance. If we consider that "moderate" intensity would be a comfortable goal for most "fitness" paddlers (as opposed to a low intensity sight-seeing drift!), then SUP meets similar calorific outputs against time as the alternatives.

	Calories Burned Per Hour			
Activity	130 lb.	155 lb.	185 lb.	205 lb.
Cycling, 12-13.9 mph, moderate	472	563	654	745
Cycling, 14-15.9 mph, vigorous	590	704	817	931
Cycling, 16-19 mph, very fast, racing	708	844	981	1,117
Cycling, >20 mph, racing	944	1,126	1,308	1,489
Running, 6 mph (10 min mile)	590	704	817	931
Running, 6.7 mph (9 min mile)	649	774	899	1,024
Running, 7 mph (8.5 min mile)	679	809	940	1,070
Running, 7.5mph (8 min mile)	738	880	1,022	1,163
Running, 8 mph (7.5 min mile)	797	950	1,103	1,256
Running, 8.6 mph (7 min mile)	826	985	1,144	1,303
Running, 9 mph (6.5 min mile)	885	1,056	1,226	1,396
Running, 10 mph (6 min mile)	944	1,126	1,308	1,489
Running, 10.9 mph (5.5 min mile)	1,062	1,267	1,471	1,675
Swimming laps, freestyle, fast	590	704	817	931
Swimming laps, freestyle, slow	413	493	572	651

repro: ilovebicycling.com

Good for the heart?

ACE also enlisted Dr Jeanne Nichols and her team at the University of California to write their paper, "Stand Up Paddle Boarding for Fitness and Caloric Expenditure".
They studied 20 paddlers, half novice and half experienced, and tested physiological criteria during calm flat water paddling as well as in a controlled lab condition on a SUP ergometer similar to this one.

They produced some interesting heart rate data. The American College of Sports Medicine considers the threshold known for eliciting positive cardio-vascular adaptation is 64% of Maximum Heart Rate (MHR). Their results for **paddling on flat water** are summarised here:

Table 4
Relative HR and Paddling Speed at Leisurely and Fast-paced Trials on the Water in Study #2

	Leisurely Pace					
	NOVICE			EXPERIENCED		
	Female (N=5)	Male (N=5)	All Novice (N=10)	Female (N=5)	Male (N=5)	All Experienced (N=10)
%HRpeak	57.9 (13.9)	51.0 (3.0)	54.5 (10.2)*	59.7 (6.9)	70.1 (6.0)	64.9 (8.2)*
Speed (m/sec)	1.42 (0.2)	1.27 (0.1)	1.35 (0.2)*	1.35 (0.1)	1.91 (0.2)	1.63 (0.3)*
	Fast-Pace					
%HRpeak	71.6 (8.5)	58.3 (10.2)	64.9 (11.3)*	74.6 (7.3)	75.8 (14.5)	75.2 (10.8)*
Speed (m/sec)	1.56 (0.4)	1.85 (0.1)	1.71 (0.3)*	1.76 (0.1)	2.49 (0.3)	2.12 (0.4)*

The key point is that at a self-selected leisurely rate the novice paddlers did not exceed the 64% MHR threshold, but they nudged up towards it at fast pace. The experienced paddlers were close, or past the threshold at both paces. Potentially their perception of a leisurely pace was influenced by more experience of specific fatigue, and technique.
The testing on the lab ergometer was done at three levels of ascending intensity from 45% of peak power to 75% of peak power. Heart rates were high and above threshold in both novice and experienced, even at 45% peak power. The researchers considered that the novice's lack of skill and experience didn't matter on the ergometer and they could therefore apply force and work harder. The considerable variation between on the water and in the lab questions the bio-mechanical demand similarity between the two. The researchers felt that as technique improves then sustainable effort levels increase which push heart rates and caloric expenditure into and beyond cardio-vascular adaptation range. It makes sense. It doesn't take much skill to stay on an exercise bike, you are unlikely to fall off a cross trainer, and you don't have to turn on a treadmill. With SUP it is a case of "technique before effort" ... and then it depends on how much you are prepared to put in.

Putting it all in

What happens if you really paddle hard?
Ben Schram et al produced "A performance analysis of a SUP marathon race" for The Journal of Strength and Conditioning research in 2017. They monitored 10 elite race paddlers over a 13-14k marathon race. Here is some of their data:

- Peak speeds were in the region of 18-24 kph
- But the most significant amount of time was spent in the 5-10 kph range
- Peak heart rates amongst the 10 varied from 168 to 208 bpm
- However, average heart rate over the race period across the 10 was 168.9 bpm
- Significantly high durations were spent in elevated heart rate zones with participants spending 89.3% of their race within 80-100% of their age-predicted HRmax.

The researchers concluded that "Marathon SUP races appear to involve a high aerobic demand". Your not kidding! That is some high cardiac demand data. When working with other endurance athletes we often use heart rate as one of the parameters to determine training zones (Coggan zones etc). It is difficult to comment on the 10 paddlers individual thresholds but just by considering that most of the race is above 80% HRmax and significantly more, we can surmise that they are primarily working at that "sweet spot" point at upper tempo zone, and I imagine pushing past threshold for recoverable bursts. That would be comparable with competitive distance cyclists and runners data.

Level	Name/purpose	% of threshold power	% of threshold HR	RPE	Time
1	Active recovery	≤55%	≤68%	<2	70-80 years
2	Endurance	56-75%	69-83%	2-3	2.5 hours to 14 days
3	Tempo	76-90%	84-94%	3-4	30min to 8 hours
4	Lactate threshold	91-105%	95-105%	4-5	10 - 60 min.
5	VO_2max	106-120%	>106%	6-7	3 - 8 min.
6	Anaerobic capacity	121-150%	N/a	>7	30 sec. - 2 min.
7	Neuromuscular power	N/a	N/a	(maximal)	5 - 15 sec.

Hearty Surfing

Staying with heart rate, Yair Suari et al produced the paper "The effect of environmental conditions on the physiological response during a SUP surfing session" in 2018.
They monitored wave height, frequency and wind speed etc... but also heart rate. Here is some of their data:

- 43 year old experienced surfer, 10 sessions, 14.9 hours of monitoring
- The heart rate was above 70% of predicted HRmax for 85% of the session time
- Whilst "paddling back to the peak" the heart rate averaged 83% of HRmax
- Interestingly during falls it raised to an average of 85% HRmax
- Not surprisingly total time actually wave surfing was less than 5% of the session

The authors concluded that "SUP surfing is an aerobic activity characterized by moderate to vigorous aerobic intensity with bouts above the anaerobic threshold during wave riding and while crossing the wave". They were open in pointing out this was a single participant study and there could be physiological variation across other surfers. However as someone who paddle surfs (badly), and having discussed the aerobic nature of surfing with many friends, the data subjectively does feel right.

I found a Youtube video by Yair Suari that was posted in 2015. I don't know if it was part of this study but it graphically shows heart rate data against surf video in real time. It's a good watch and you can view it via this link:
https://www.youtube.com/watch?v=YFVgBa5gRYg

The Total Body Workout

There are multiple components of the thing we call "fitness". Ben Schram et al decided to look at 4 of these in their study "The physiological, musculoskeletal and psychological benefits of paddle boarding", 2016. Namely these were CV fitness, multi-directional core strength, balance, and self rated quality of life (physical and psychological). Their cohort were 13 participants who led sedentary lifestyles and were unfamiliar with SUP. They performed some extensive profiling to get a baseline of the groups fitness within a 6 week initial rest period/normal lifestyle. Then they took them through a 6 week structured SUP development programme. All had three 1hr SUP sessions a week, with rest days in between. They progressed from long wide beginner boards to narrower shorter boards to challenge postural control as the weeks progressed. They increased paddle distances to challenge endurance (up to 10k paddles by the end of the programme), but they also incorporated sprint and interval sessions. Participants were instructed to perform no other physical activity apart from the SUP training during the interventional period. The periodic testing included blood tests, gaseous exchange analysis, metabolic metrics, force platforms, balance seesaw test, multi-directional trunk strength tests and a quality of life questionnaire. And to keep the data reliability all 13 got to play with one of these bad boys in the lab during the monitoring sessions:

There was much more to the study than I have outlined. The authors were keen to stress that it was a relatively small group , and that there was no independent control group. However the cohort specific initial rest period provided a comparative control. They were humble enough to point out that a similar intervention using walking/cycling/recumbent/treadmill training may get similar results if applied to a group of untrained individuals. I'm not entirely sure that the other options would have achieved the trunk strength and relative power gains, and I'm not certain that pounding a treadmill for 6 weeks would have facilitated the quality of life improvements. Researchers can't be" loud and proud" by nature (or science), so I'll do it for them. This study was extremely well planned, comprehensive and committed. The results and conclusions were realistic, and the level of "evidence" extremely helpful for the development of the sport within the health and well-being environment. I will summarise some of its outcomes but you can read it here:
https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5057214/

- Across the group there was a 23.57% increase in aerobic power
- There was a 41.74% increase in anaerobic power output
- There was a 42.11% increase in relative power output

- The distance covered in 10 secs ergo test (power) improved by 12.37%
- Trunk strength averaged across the 4 combined test directions improved by 23.9%
- There was no significant change in static and dynamic balance testing
- The combined physical and psychological quality of life rating improved by 18.74%

They are positive findings, although the authors seemed a bit surprised by the lack of balance improvement. Balance is difficult to test functionally, often appears to be "skills-specific", and lets face it, may not be the most important component of fitness... so you can eat a burger on one leg.

The authors intro states "SUP is a rapidly growing sport and recreational activity where anecdotal evidence exists for its proposed health, fitness and injury rehabilitation benefits". Their conclusion states "This study shows significant improvement in aerobic and anaerobic fitness, multidirectional trunk endurance, and self-rated quality of life measures, can be elicited by SUP participation for previously untrained individuals". I think that says it all.

What about long term?

Ben Schram and his team have been studying this area as well, publishing a case study in The International Journal of Sports and Exercise Medicine in 2017, "The long term effects of SUP: a case study".
They took a 58 year old male and a 58 year old female and tracked them through a year of SUP training and participation. Again they saw significant improvements in aerobic fitness, increase in trunk muscle endurance, and over this longer time period they saw a significant reduction in Body Mass Index.

Case studies are a great way to document and present "real world" examples of change. I have also heard folks describe them as "evidence by example". Either way it was another well planned study and can be read here:
https://clinmedjournals.org/articles/ijsem/international-journal-of-sports-and-exercise-medicine-ijsem-3-065.pdf

Schram and his colleagues Wayne Hing, Bond University, and Mike Climstein, Southern Cross University have been very busy. Back in 2015 they threw their battery of tests at 15 elite SUP, 15 recreational SUP and 15 sedentary folks, publishing "Profiling the sport of SUP". I position this study here because to become "elite" we are going to presume they were relatively long term participants. Here's a snapshot:

- Holding a prone bridge av: Elites 253 secs, Recs 165 secs, Seds 69secs... ouch.
- Elites and Recs... significantly lower body fat than Seds.
- Max oxygen uptake: Elite 43.7 ml/kg/min, Rec 31.9 ml/kg/min, Sed 20.4 ml/kg/min
- The elites had great cholesterol and lipid results as well... and were probably better looking.

I guess the results are probably not overly surprising, but the elites figures do stack up well, and the authors were justifiable in stating, "SUP appears to be associated with increased levels of aerobic and anaerobic fitness, increased static and dynamic balance and a high level of isometric trunk endurance".

The Good, the Bad and the Injured

So it's all been very positive and healthy so far, but what can a SUP session cost in terms of injury? James Furness, Bond University, and his co authors, decided to find out, revealing their results in "Epidemiology of Injuries in SUP" published in 2017. They surveyed 240 paddlers who reviewed their previous 12 months. 95 of them had sustained one or more injury during the time period.

TABLE 4
Location of Injuries and Comparison of Recreational and Competitive Stand-Up Paddleboard Riders

Site	Injuries		Recreational Injuries, n[a]	Competitive Injuries, n[a]
	n[a]	%		
Head/ face	8	5.0	5	3
Neck	6	3.7	3	3
Shoulder/upper arm	53	32.9	12	41
Elbow/forearm	19	11.8	4	15
Wrist/hand	3	1.9	1	2
Upper back	5	3.1	2	3
Rib	12	7.5	5	7
Lower back	23	14.3	7	16
Hip/groin/buttock	6	3.7	4	2
Knee	10	6.2	1	9
Shin/calf	4	2.5	2	2
Ankle/foot	12	7.5	6	6
Total	161	100	52	109

[a]Refers to the number of injuries.

Above are some of the results, but these are the headlines:

- Most common locations: Shoulder/upper arm 32.9%, Low back 14.3%, Elbow/forearm 11.8%
- Most common type: Muscle/tendon 50.4%, Joint/ligament 22.6%, Skin 14.2%
- Most common causes: Endurance paddling 34.5%, Board contact 20.1%, Sprinting 14.2%
- And the factors most likely to increase injury risk are: increased age, being in competition and increased time on the water

I liked this research paper because it is possible to do some classical "extrapolation" from its results. Take the most common of the most commons above. You have got an old bloke, who has over-stretched himself with an ambitiously long paddle, who has sustained a muscle overload injury, and it's to his left shoulder... that's me right now. It's also a typical presentation that I see in the clinic.
As the sport develops may be we will see some different injury trends...

white water paddle boarding

The Conclusion

Just going on intuition you would expect paddleboarding to be an activity that will contribute to the participants health and fitness. There's all the loading, or pumping up, the carrying to the water, the physicality of the session, the wrestling with wetsuits, carrying again, loading, unloading... and it's all outside dealing with the elements. It's a no brainer... which is a phrase I particularly dislike. No braining is accepting what you think is right, rather than investigating and learning what is really right. Thankfully the researchers that I have reviewed here have done some serious braining for us. They have broken down many of the components of health and fitness and analysed these in relation to SUP. They have provided data that we can compare and contrast against other activities. They have given us figures where we only had guesses. Best of all, we now have evidence rather than intuition.

Thankfully the evidence is favourable, which is good news because SUP will continue to grow. It is a highly adaptable activity, already off-shooting into white water, tethered classes, fishing, paddle polo, safari etc, as well as its core disciplines. SUP can grow without research, but if we let it, we wont truly understand the role it is playing right now, and the role it can play in the future, when it comes to health, fitness and sport.

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Bob Wood is a UK based physiotherapist and lecturer living and practicing in Norfolk.
He has produced athlete development resources and strategies for various governing bodies, organisations and teams. He presents courses on rehabilitation, physical training and evaluation.
His blog is fun, you should read and watch it here: https://www.physical-solutions.co.uk/blog/
Bob is currently engaged in a research project investigating Delayed Onset Muscle Soreness (DOMS) within SUP.

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