Total Calories Burned While Kayaking

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What affects calorie expenditure during kayaking?

You might be interested in knowing this to help you figure out your calorie intake needs (there is another article on this topic) for performance or you are interested in losing weight and want to use kayaking to burn calories. To get to the answer to the question above, let's start by considering several factors. First, close your eyes and imagine a person exercising. That person could be you or not, and it could be any form of exercise, your choice. Now ask yourself, "How many calories is this person burning?" Now we can begin thinking about all those factors that determine the rate at which calories are burned during exercise. Those factors affecting the rate of calorie expenditure are the following:

Type of exercise being performed
Amount of muscle mass recruited (very much related to the type of exercise)
Intensity of exercise
Duration of exercise (inversely related to intensity of exercise)
Body mass (during weight-bearing activities)
Muscular efficiency
Primary fuel source

Before we consider each of these factors, I want to clarify one point. When discussing calorie expenditure (burning calories), there are two ways to look at it. First, as a total number (total calories burned while kayaking during 4 hours for instance) and second, as a rate (calories per minute or calories per hour).

How does the type of exercise affect total calories burned?

The type of exercise performed is characterized by several things; the amount of muscle mass recruited, the repetitiveness of the movements, the duration of the movements, and amount of force and power generated by the muscles. Two activities on opposite ends of the spectrum are the Olympic power-lift and an ultra-distance running event. The former lasts a few seconds, requires almost all the muscles in the body, and is very explosive. The latter lasts several hours, uses primarily leg muscles, is repetitive and relatively low in force or power generation. In terms of calorie expenditure, obviously the runner will expend the greatest total number of calories, however the rate at which he or she is burning them is much less than the powerlifter.

Comparing calorie expenditure gets a bit trickier when you compare activities that have more similarities between them, like long-distance kayaking and long-distance cycling. Both involve a large amount of muscle mass and both are repetitive for long periods of time. Typically, we are talking about activities that could be categorized as endurance or aerobic activities.

When you compare endurance activities, the amount of calories burned is very much related to the amount of muscle mass recruited. One way to picture this is to consider a person in a wheelchair who cannot recruit muscles from his or her lower limbs; he or she must rely totally on upper body and trunk muscles to propel the wheelchair. The muscle mass involved here is much less than an experienced kayaker who is engaging his or her leg muscles as well as upper body and trunk muscles for paddling. Thus, the person in the kayak has a greater potential to burn calories.

How does the intensity of exercise affect total calories burned?

For any given type of activity, the intensity at which it is performed is the most significant factor in the rate at which calories are burned. The higher the intensity, the higher the rate of calories burned. But, this is not the case for total calories burned. This is because intensity of exercise is inversely related to the duration of exercise; the more intense it is, the less time you can spend doing it before needing to stop or slow down. Here's an example of how this works for a 75-kg (165-lb) person walking or running on a treadmill:

Treadmill speed	calories/minute (rate)	Duration exercise can be sustained without stopping	Total calories burned
3.0 mph	4.3	60 minutes	260
6.0 mph	13.4	8 minutes	105
9.0 mph	19.4	30 seconds	10

From the table, you can see that duration and rate of calories burned are inversely related, both play a big role in determining how many calories one burns during exercise. But, if you could run at 6 mph for 60 minutes, you have a greater rate of calorie burning going on compared to walking at 3 mph, thus much greater total calorie expenditure. As you train and become more fit, you increase your calorie expenditure potential.

How does body mass affect total calories burned?

Body mass can also affect calorie burning, at least during activities that are "weight-bearing". These are activities such as running, walking, skating, stair stepping machine exercise, and elliptical trainer exercise to name a few. Weight-bearing simply means that you are moving your body against the force of gravity, thus the heavier you are, the more energy it will take to move your body against gravity. Some activities are non weight-bearing, like cycle ergometry (cycling outside is a bit different because sometimes you must propel your bicycle up a hill). What about kayak ergometry or kayaking on the water? Obviously, the heavier you and your boat are in the water, the more resistive forces you'll have to overcome, thus requiring more energy to maintain a given velocity and stroke rate. Of course, the amount depends on many things such as the design of the boat, how the weight is distributed, tidal currents, waves, wind, etc. With a kayak ergometer, you don't have any of these issues and thus, it is non weight bearing in nature.

When performing a weight-bearing activity, the greater the body mass, the greater will be the rate of calories burned. Here's an example of how that looks among 3 people of very different body masses walking or running on treadmills:

If each person runs at 6.0 mph for one hour, the heaviest person will have burned a third more than the 165-lb person and twice as much as the 110 lb person (1068, 804, 534 total calories, respectively).

Numbers are calories/minute

	50 kg (110 lb)	75 kg (165 lb)	100 kg (220 lb)
3.0 mph	2.9	4.3	5.8
6.0 mph	8.9	13.4	17.8

How does muscular efficiency affect total calories burned?

Another factor that will affect calories burned during exercise is muscular efficiency. Technically, efficiency refers to the ratio of mechanical power output to metabolic power. In a lab, both can be measured accurately. Mechanical power output can be easily determined on an ergometer. When riding a cycle ergometer for instance, you see various display options. One option is "Watts". That number is your power output on the ergometer. The same can be displayed on a stairstepping or elliptical machine. Rowing ergometers also show power output. You won't see that on a treadmill, because technically, work is not performed while walking or running. Metabolic power refers to the rate at which calories are burned. Metabolic power could be aerobic or anaerobic, or a combination of the two. In order to accurately quantify metabolic power, measures must be performed in an exercise physiology laboratory.

Typically, muscular efficiency values are somewhere around 20%, give or take 5%. Basically, efficiency tells you how well you can convert chemical energy into useful energy (the majority is wasted on heat), such as propelling a paddle through the water or pedaling a gear on a bicycle. If your efficiency is 20%, this simply means you can convert 20% of your chemical energy into useable or mechanical energy. As a general rule, for most any repetitive-type activity, the more skilled and experienced a person is, the more efficient they are. They can get that value up above 20% for instance, meaning they can convert more chemical energy into useful energy. What this also means is that a skilled person will expend fewer calories for any given power output performed compared to an unskilled person. This could help the skilled person during a long race because he or she will not fatigue as quickly and they can increase their power output more effectively when necessary.

An interesting study concerning muscular efficiency and cycle performance came out of The University of Texas at Austin where Lance Armstrong (7-time Tour de France winner) was studied for several years, pre- and post-cancer treatment. Over the years, the most significant improvement concerning Lance's cycling performance was the fact that he experienced a 8% improvement in muscular efficiency, which in turn increased his maximal power output at a given maximal metabolic rate. In other words, at a given rate of energy expenditure, he could push a greater amount of power through his incredibly efficient muscles. Among several studies with mostly runners and cyclists, muscular efficiency has been shown consistently to be an important determinant of endurance performance.

So how much of a difference does muscular efficiency make in energy expenditure? As a general rule no more than 5 to 10%. In other words, if you take the least efficient kayaker and compare them to the most efficient kayaker, there will likely not be more than a 10% difference in the rate of calories expended at any give power output.

What affect does fuel source have on total calories burned?

The last factor listed is primary fuel source, which is getting nitpicky. In a nutshell, if you burn 100% fat (which is virtually impossible) you will expend about 5% fewer calories than if you burn 100% carbohydrates. The point is, rarely if ever do we experience these extremes. Most of us consume a mixed diet of carbs, protein and fat and unless we are exercising at a completely anaerobic level, we are relying on a mixture of fuels at all times. So for all intents and purposes, fuel source really does not factor in when considering calorie expenditure.

How can I determine the number of calories I burn while kayaking?

Now let's talk specifically about kayaking. How many calories can one burn during a long distance kayaking trip or competition? The answer to that depends on some things like intensity (speed of the boat for instance), duration, body mass (plus mass of boat and contents), skill level, and various environmental factors such as wind speed and direction, and tidal currents. If you go to the following web address and open up the pdf document: http://prevention.sph.sc.edu/tools/docs/documents_compendium.pdf, you'll find a list of activities several pages long (I refer to this document several times in this reading). In fact, you would be hard pressed to NOT find an activity; it includes activities such as digging worms with shovel, building a fire inside, airplane repair, playing a woodwind instrument, furriery, orange grove work, hugging and kissing, hacky sack, bird watching, and spiritual dancing in church, to name a few. But most importantly, it includes kayaking, as well as canoeing at various speeds and canoeing-related activities such as portaging and harvesting wild rice. There is only one entry for kayaking and it is compcode 18100. By the way, the compendium is a compilation of decades of research and updated every 10 years or so. It is often referred to in studies that seek to quantify total daily energy expenditure in individuals.

So what does this compendium tell you? It tells you how many calories you burn when performing an activity. The compendium does not provide calorie units, rather it uses a unit of measure called METS.

METS is a simplified way to quantify the relative energy cost of activities and it can be converted easily to calories. The MET value for a specific activity is a multiple of what you would expend while lying and doing nothing, your resting metabolic rate. During rest, your MET level is 1.0; thus, 1 MET is equivalent to your resting metabolic rate. A MET value above 1.0 refers to almost all other activities.

1 MET is equal to 1 calorie/kg body mass/hour. In other words, the number of calories burned per hour while at rest is equivalent to your body weight value in kilograms. Here's an example of how to calculate that very easily:

Your body weight = 165 lb
Convert this to kilograms: 165/2.2 = 75 kg
1 MET = 75 calories per hour
75 cal/hr X 24 hr/day = 1800 calories per day

In other words, while laying and resting for one hour, you burned approximately 75 calories if you weight 75 kg. If you multiply that by 24, you have a rough approximation of your daily resting metabolic rate (in this case, 1800 calories).

Going back to the compendium list, find compcode 18100, which corresponds to kayaking. You will see the MET value is 5.0, meaning you expend 5 times the amount of calories while kayaking compared to lying and doing nothing. But this still doesn't give you the absolute number of calories. And, savvy reader, you've probably already figured out that there are various levels of kayaking, and fewer or more METS could easily be assigned, depending on those factors we've been talking about earlier.

But, as a starting point, let's convert 5.0 METS to calories, so we have something to work with. Using the same calculations as above:

Your body weight = 165 lb
Convert this to kilograms: 165/2.2 = 75 kg
5 METS = 75 kg x 5 calories/kg/hour = 375 calories per hour
To get Calories per minute:
375 kcal/hr ÷ 60 min/hr = 6.25 Calories per minute

How does one hour of kayaking compare between different weighted people?

	50 kg (110 lb)	75 kg (165 lb)	100 kg (220 lb)
Calories/min	4.2	6.25	8.3
Calories/hr	250	375	500

Now you can get an estimate of the number of calories you're burning during a long-distance paddle. For instance, if you are planning a route that will take you 4 hours (based on your average moderate pace of 3.5 mph and total distance of 14 miles), you can estimate the total calories expended during that trip by simply multiplying your body weight (in kilograms) by 5, giving you Calories/hr and then multiply that by 4. If you weigh 75 kg, that's 1500 Calories in total. How accurate is this? Consider that you may have stopped occasionally, maybe got out of your boat for a short break or drifted awhile taking photographs. Maybe you had a tidal current on your side making paddling much easier. Maybe you had a head wind during the final 2 miles of the trip, making paddling more difficult. So you can see it's not totally accurate, and should be used as an estimation allowing for error in either direction.

From where does the MET level of 5 for kayaking come from? Most studies (with one or two exceptions) investigating kayaking physiology have relied on kayak ergometers for their protocol. The good side of this is that intensity can be controlled and changed at specific times, thus providing more meaningful data. This allows investigators to study many aspects of kayaking physiology, like cardiovascular or metabolic responses, maximal aerobic and anaerobic power, muscular efficiency, or effects of training, fatigue or nutrition on performance. The bad side is that it does not truly reflect a true kayaking situation on the water. Therefore, it becomes difficult to apply precisely those data derived under very specific conditions to a real kayaking experience. Always keep this in mind when you read about the results from a particular study. If it's a good study, it adheres to controlled conditions, including the selection of participants in the study (e.g., elite kayakers, women, older adults, etc). So what applies to that group may not necessarily apply to you.

One last interesting tidbit on this topic. Ever hear of drafting in the sport of cycling? It is an effective way to lower the metabolic cost of cycling, but still maintain the pace necessary to keep up with the group. One cyclist leads and the others follow either directly behind in a straight line or in a diagonal line, one rider in front of another. There is barely 2 inches between the rear tire of the cyclist in front and the front tire of the cyclist behind him or her. This actually reduces caloric expenditure by 15%, give or take, a substantial decrease considering the intensity of cycling. A similar effect can be seen in kayaking when using the "wash riding" technique (Gray et al), a racing strategy used for flatwater kayak and canoe racing. The paddler positions his or her boat on the wake of the boat in front. Gray et al discovered that the energy expended while wash riding was about 11% lower than when it was not used. This could be a substantial energy saver for long distance paddling when in a group or a pair. Like with cycling, the lead kayaker can fall back after about a minute of leading and let the second in line take over. Paddlers would simply rotate the lead position. The more paddlers there are, the less time you spend in the lead, thus conserving energy. The neat thing about Gray's study is that they used a portable metabolic system that allows energy expenditure to be measured while kayaking in the water. The portable system is relatively new and is being used in many studies to validate the compendium's values for various physical activities that are difficult to measure in a laboratory when a person is connected to a large non-portable machine by a hose. With the portable, movement is not hindered and a person can go about their daily activities while energy expenditure is measured easily.

How many calories do I burn during a long-distance kayak race?

Now we can work toward estimating total calories burned during multi-day trips or competitions. I'll start with competitions because that is very straightforward and doesn't involve too many extraneous activities. It would be safe to estimate total energy expended in one day just by calculating the total calories burned during kayaking.

Above, I gave you a value of 5 METS for energy expended while kayaking. My guess is that the competitor is achieving twice that amount during a race. How do I figure this? I based it on the only 2 studies I know that actually measured energy expended (via oxygen uptake measures) during steady state paddling in experienced/elite kayakers. The first study (Gray et al, Int. J. Sports Med., 1995) measured energy expenditure directly while elite kayakers paddled in the water at a steady state pace. These guys averaged 83.9 kg in body mass and exerted an effort requiring approximately 12 METS. The second study (Bishop, Int. J. Sports Med., 2004), measured oxygen uptake in experienced kayakers while paddling on an ergometer at a pace set at lactate threshold. Lactate threshold, in a nutshell, is right about where a long distance competitor would be, intensity-wise. The athletes in this study weighed 72.2 kg and paddled at an intensity of approximately 11 METS.

Here's another study, but with a cyclist competing in the Race Across America (RAAM). Knechtle et al estimated total energy expenditure in one male cyclist during his 10 day cycling event. He averaged about 290 miles over 20 hrs of cycling each day and it was estimated that he expended on average about 18,000 calories per day. Based on the compendium's MET level for cycling and the average mph (about 15 mph), he would be cycling at 10 METS. This is comparable to what I estimated for the competitive kayaker.

Using these numbers, an athlete in a single kayak who is competing in a long-distance paddling event of, say 300 miles and averages 5 mph in his or her kayak will be paddling for 60 hours in total. Let's say that included on average 15 hours of paddling in one day over a 4 day period. If he or she is at a 10 MET level, this is how many calories that person would burn while racing:

50 kg (110 lb)	500 cal/hr	7500 cal/day
75 kg (165 lb)	750 cal/hr	11250 cal/day
100 kg (220 lb)	1000 cal/hr	15000 cal/day

So why don't I calculate total daily calories for the competitor? Simply put, why bother? Look at the numbers above and tell me if a 165 lb person is going to consume 11240 calories in one day and do it while paddling. It just isn't going to happen. The point is, during a multi-day competition, an athlete must come to terms with the fact that he or she will go into caloric deficit during that period of competition. This may or may not have significant negative consequences, and if the athlete is mindful enough of his or her diet, adequate carbohydrate and protein will be the key to avoiding some of these negative consequences. I'll talk about nutrition in more detail in another article, but for now, I'll go back to the study about the RAAM cyclist. Energy intake was also measured in this study and the cyclist averaged about 9600 calories each day. This is a lot of calories to consume in one day and much of this can be done while cycling. But, when you compare that to his average expenditure, the athlete was in a 8300-calorie daily deficit on average! Interestingly, he lost only 5 kg (11 lb) of body mass. The bottomline, eat as much as you can, whenever you can; and allow complete recovery after the race.

What is my total daily energy expenditure during a multi-day kayak trip?

It would be safe to say that a fairly experienced paddler who is not in racing mode would paddle at a leisurely pace of 5 METS, whereas a paddler who is racing would be closer to 10 METS. If you want to estimate your calorie expenditure for a multi-day kayaking trip, which number works for you? Using my own experience paddling in the Everglades as an example, on any given day I go from very leisurely to lactate threshold steady state intensity. This all depends on weather conditions, tides, my paddling companion(s), time, etc. For me, 5 METS seems to be a reasonable estimate for average energy expenditure. Continuing along these lines, I'll use my experience with kayak camping to demonstrate how total energy expenditure can be estimated for a kayaking trip. I weigh about 70 kg (155 lb).

During a typical kayak camping day, I may paddle for as little as 2 hours to as much as 5 hours, but rarely outside of this range. This is not including the time spent drifting (e.g., fishing, kayaking, taking a break) or getting out of the boat for a rest stop. For my example here, I'll use a 4-hr paddle day. If you go back to the compendium, you'll find several activities that fit the typical kayak camping activities. The list does include one entry for camping (compcode 09110), but it appears to take into account everything you might do while camping like sitting, standing, walking and light to moderate effort activities. I wanted a more accurate estimate so instead of using compcode 09110, I've broken up the camp activities into the following:

Setting up or breaking camp (tent up/down, packing/unpacking)
Carrying bags to & from kayak (distance depends on tides)
Carrying firewood
Carrying the kayak (when empty and with another person)
Walking and photographing/exploring
Meal preparation
General camp chores other than meal prep (grooming, eating, washing dishes)
Quiet sitting (eating, drinking wine, socializing, reading)
Quiet standing (around campfire, fishing, in general)
Quiet lying (in tent reading or sleeping)

You won't find all of these specific activities in the compendium, so I found an activity that comes closest to describing each one. Here's how that worked, including all the activities and their MET levels:

Setting up or breaking camp (tent up/down, packing/unpacking): METS = 2.1
For this I used the combination of compcodes 05090 and 05095, which is implied standing and walking, respectively. I chose these because they include activities involving folding laundry, packing clothes, making bed, etc. Putting up and taking down the tent is not much more than that exertion-wise (I typically share this task with my paddling partner).

Carrying bags to & from kayak (the distance depends on tides): METS = 3.5
In the heading category of "occupation", I found custodial work –taking out the trash (code 11127) and farming – hauling water for animals (code 11191) as being similar to carrying bags to and from the kayak. At least one of those bags will contain 1-2 gallons of water, so I combined these to come up with an average MET level, favoring the lower end.

Carrying firewood: METS = 3.5
Similar to carrying bags to and from the kayak, so I used the same MET level here (I tend to load up with firewood in my arms).

Carrying the kayak (when empty and with another person) METS = 7
Since there is no "carrying kayak" category, I used the "canoeing, portaging" category (code 18030). It's probably an overestimation because I have another person helping me and we carry them when they are empty. But, the amount of time spent doing this is very short, so error is minimal when calculating the total daily calories burned.

Walking and photographing/exploring METS = 2.5
I used birdwatching (code 17085) as a comparable activity; it takes into account a leisurely walking pace.

Meal preparation METS = 2.0
This one needs no substitution, code 05050, standing or sitting while cooking.

General camp chores METS 1.5
I use a combination of self care activities (codes 13000s) such as bathing (sitting), eating (sitting), dressing and grooming to come up with an average.

Quiet sitting (eating, drinking wine, socializing, reading) METS = 1.0
This one needs no substitution, code 07020, sitting quietly

Quiet standing (around campfire, fishing, in general) METS = 1.2
This one needs no substitution, code 07040, standing quietly

Quiet lying (in tent reading, napping or sleeping) METS = 1.0
This one needs no substitution, code 07010, lying quietly

Paddling METS = 5.0

Breaks during paddling METS = 1.0
I use quiet sitting as the category here.

Now that I have all my activities and their corresponding METS, I then determine how much time I spent doing each activity. Some activities are not done all at once; rather, they accumulate throughout the day. Once I get this estimate, I can now calculate total calories expended for each activity and add them up for the grand total. To do this, use the following equation (remember, you need to convert body mass to kilograms by dividing pounds by 2.2):

METS X your body mass in kg (lb/2.2) X hours spent doing activity

Here's how it works (note, I rounded to the nearest whole number for calories):

Activity	METS	Time (hours)	Calories (METS X mass X time)
Set up/break camp	2.1	1.0	147
Carry bags	3.5	.50	123
Carry firewood	3.5	.35	86
Carry kayaks	7	.15	74
Walking/exploring	2.5	2.25	394
Meal prep	2.0	1.0	140
Camp chores	1.5	.75	79
Quiet sitting	1.0	2.5	175
Quiet standing	1.2	.5	42
Quiet lying	1.0	9	630
Paddling	5.0	4	1400
Paddle breaks	1.0	2	140
TOTAL		**24**	**3430**

I estimated these times as close to reasonable as possible. With respect to carrying the kayaks, often we must move our boats over several hundred feet of sand if at low tide, so the amount of time can vary somewhat. I estimated it here to be about 10 minutes, allowing for 2 kayaks to be moved each way and over about a 200-ft distance one way. The same thought applied to the carrying bags to and from the kayak.

As you can see from the table above my estimated total daily energy expenditure is 3430 calories. If you kayak camp, it is likely that the above activities will work for you as well. You may have to add some categories such as chopping or sawing wood, fishing, running, hill or rock climbing, backpacking, portaging, etc.

What do you do with this information? Mostly, you can now estimate the total calories you would need in order to remain in energy balance. Keep in mind, the same approach can be taken as with the competitive kayaker, in that, you may not be able to stomach or find the time to eat that many calories. I can assure you that I don't consume 3500 calories daily on my trips. I discuss calorie intake in another article.

Can women burn as many calories as men?

The simple answer to that question is 'yes'. But this depends on several factors including fitness level. Obviously, a trained female marathon runner will burn more calories while running than a man who hasn't run for years and decides to start a running program. In terms of calorie expenditure; the simple truth is that women have less body mass than men (on average) and this means men burn calories at a faster rate than women (on average). If you go a bit deeper and consider body composition (or what comprises body mass), women have proportionally more body fat and less muscle mass than men. This also affects calorie expenditure.

The best way to equate men's and women's calorie needs is to compare them at equal levels of training experience and exercise intensity. If these 2 people are paddling under identical conditions and intensities, the man will burn calories at a higher rate. Resting metabolic rate will typically be higher in a man and he will require more calories to perform just about every activity listed above during a kayak camping trip. Always consider body mass when calculating calorie expenditure, but keep in mind that body composition does have an affect and will explain variations among individuals. But for a decent estimate, both men and women can use the above calculations. I'll discuss body composition and sport performance in another article.

What about calories burned during canoeing?

By no means do I wish to ignore the canoeists out there, but every calculation that applied to kayaking will apply for canoeing as well. One advantage for the canoeists who relies on the compendium list is that there are 8 categories for canoeing, compared to only one for kayaking. One of those categories is portaging which is equivalent to 7.0 METs. One category, canoeing, harvesting wild rice, knocking rice off the stalks, will most likely not apply here; although it may be comparable to bushwacking your way down a narrow river that hasn't been traveled much (I had that experience in the Everglades). The other categories are based on speed of rowing from 2-3.9 mph (light effort) to > 6 mph or competition (vigorous effort), ranging from 3.0 to 12.0 METs. Once you decide on a category for your needs, the above calculations will apply just as well as they did for kayak camping.