8) WHERE ARE THEY NOW? Report on a 22 year Longitudinal Study of Elite Distance Runners

You Sure Can Get Old Studying Aging!

In research involving age related changes in physical function, there are two basic types of studies. The first and most common is the CROSS SECTIONAL study. In this type of work, an investigator recruits groups of people of different ages and/or activity levels and makes comparisons. In a sense, we are trying to take a snapshot of each group. For example, the MARS study that I have been working on is comparing the training habits of rowers in their 40s, 50s, 60s and 70s by decade. This is a reasonable approach (and the only one when the age difference is 40 years!) and we are learning a great deal of information. However, there is another way. This is the LONGITUDINAL STUDY. Here we examine a group of people at time A. Then we wait, and wait . . . and wait. Eventually time B comes along and we reevaluate the same people. To be honest this type of study isn't very good for a young scientist's career. They take too long! (unless you study aging in insects or rats since they have short life-spans.) But, they are an ideal; method. Fortunately, we have a few "senior" exercise physiologists around the world who began studying elite athletes before you could even earn a Ph.D. in "exercise physiology". Dr. David Costill is one of those few.

My introduction to Dr. Costill first came through a book by the late Jim Fixx called "The Complete Book of Running", written in the late 70s. One of the last chapters was called "The Scientists of Sport", and profiled the developing work of Dr. Costill. During that time he tested over a hundred elite runners. He measured maximal oxygen consumption, economy, fiber type, etc., all variables that we now know contribute to endurance performance. Well, at that time I was a kid who went to 8th grade track practice in the morning, then worked in my own private self-built laboratory at night. After reading this chapter, my future became clear. I would be one of those new "sport scientists".

It has been over 15 years since then. I have earned a Ph.D. and am still in love with this exciting field of exercise physiology (but I do not miss 8th grade track practice!) I have now met Dr. Costill in person several times. And he is still doing research. Now, in 1996 he (and his colleagues) has published something else that really caught my eye. Over 50 of those elite runners of the late 60s and early 70s recently returned to his lab to undergo the same tests they performed over 2 decades ago. This study provides us with one of the rare long term longitudinal studies of physical performance in well trained individuals. Since I kind of owe a debt to Dr. Costill from years ago, and feel this study speaks directly to many of the issues I talk about on the MAPP, I want to give it a pretty close look.

This is the reference for those who have access to the source:

Journal of Applied Physiology 80(1):285-290, 1996
Aging among Elite Distance Runners: A 22-yr Longitudinal Study
SW Trappe, DL Costill, MD Vukovich, J Jones, & T Melham.
Human Performance Laboratory, Ball State University, Muncie, Indiana
THE SUBJECTS- Description of the groups

Fifty three men were recruited from Dr. Costill's data base of over 100 runners tested in the late 1960s and early 1970s. The average age of the group when they were first tested was 29.4 years, but ranged from 18 to 55 years. From this group, four subgroups were selected based on their activity level over the intervening 22 yr. (average) period. The group selections were made based on interviews and questionnaires. The four groups were divided as follows: 1) those who continued to train intensely and compete in age group competition (10 men). We will use the shorthand he used and call this group **HT, (highly trained).** A second group was called **FT (Fitness trained)**. These 18 men continued to exercise over the 22 years but did so only for physical fitness. A third group (15 men) consisted of those who had not been regularly active for the last 5 or more years. This group was called **U T (untrained)**. Finally a fourth group was composed of older athletes who were in their mid 40s when first tested and had continued exercising for physical fitness They were called **FO (fit older).** These men were now all over 60 and more than 20 years older than the members of the other three groups. However, they had maintained a high level of fitness over the last 20-25 years.

TRAINING HISTORY

Us endurance guys like to keep training logs. These guys were no different. So this information was used to make comparisons of training volume, intensity and duration back in the 70s, in the intervening years, and currently. I have taken the liberty of reproducing that data (and a lot more to come) as reported in their research article in the Table below.

GROUP	Training Distance (km/week)	Training Pace km/hr	Training Frequency sessions/week
		Initial Period (1966-1976)	
HT	125.5	14.1	6.3
FT	98.7	13.7	6.4
UT	94.5	13.9	6.4
FO	62.7	13.6	6.1
		Intervening Period (1977-1987)	
HT	92.5	13.6	6.1
FT	66.8	12.5	5.5
UT	NT	NT	NT
FO	46.0	11.1	4.9
		Recent Period (1988-1993)	
HT	71.4	13.5	6.1
FT	43.7	12.2	5.5
UT	NT	NT	NT
FO	23.4	9.6	4.1

Back when these athletes were first tested, they were all training for competition at the local, collegiate, national, or international level. One thing is clear. All of them have decreased their training load. Even the HT group has decreased training volume by over 25%. However, the hard training group has maintained very similar intensity and frequency levels, compared to 20 years ago. It is also interesting to note that those guys who were putting in the most miles then are still putting in the most miles.

Training Status and Body Composition

The first "physiological" data we will look at are body fat and muscle mass changes among the groups as reported in the study. Sad to say, everyone gained some weight, but not everyone gained the same amount. Not surprisingly, the guys that stopped training altogether gained the most weight. And it wasn't muscle. The UT group went from 145 to 178 pounds (66 to 81 kg). Their bodyfat percentage rose from 9% to 22%. In contrast, the hard training (HT) group gained much less fat. Their bodyfat rose from 7.5% to 12.5%. The FT and FO groups were both in the middle. Their body fat rose almost identically from about 10 to about 17%, 22 years later. One other point; **The older guys also lost some muscle mass (about 7 pounds)**, while the other three groups did not. **This supports the notion that running alone is not sufficient to prevent the significant muscle atrophy that is known to occur after age 50-60.**

VO2 max, Heart Rate max etc. Then and Now (22 years later)

	UT (n=15)		FT (n=18)		HT (n=10)		FO (n =10)	
Variable	Then	Now	Then	Now	Then	Now	Then	Now
VO_2 max L/min	4.61	3.87	4.51	3.76	4.57	4.17	3.98	2.74
Percent Decline	18%		17%		**9%**		31%	
VO_2 max ml/min/kg	70.7	46.7	64.1	48.9	69.8	59.2	60.3	40.7
Percent Decline	34%		24%		**14%**		33%	
Maximal Heart Rate	187	178	186	174	191	180	175	155
O_2 Pulse	24.6	21.3	24.3	21.7	24	23.2	22.9	17.8

Maximal Oxygen Consumption

The first thing that jumps out at you from the table above is the dramatic decline in maximal oxygen consumption in those former elite runners who have become sedentary. "Use it or Lose it" definitely applies here. Their absolute VO2 declined 18%. However, because of their weight gain over two decades, their VO2 per kg bodyweight declined 34%! This 17% decline per decade is actually greater than the 10%/decade typically observed in the adult population. This is due to the fact that they had attained a highly trained state before becoming sedentary. In contrast, the absolute decline in maximal oxygen consumption was half as much in the hard trainers (9%, or about 5%/decade). And because of their lower weight gain, the decline in V02 max factored for bodyweight was also much less pronounced. Within the HT group, there were two athletes whose results were almost identical (2% decline) to those from 20 years before. Not surprisingly, their training level had been the most consistent from past to present. The decline observed in the Fitness Trained (FT) group was also greater than HT. This is explained by the significant decrease in intensity and volume of training by this group. Finally, it is difficult to interpret the results from the Fitness trained old group (FO). Their VO2 max declined more dramatically during the 22 year period, but so did their training level.

Maximal Heart Rate and Stroke Volume

Maximal heart rate

Why does VO2 max decline? Remember the central role of heart function. Maximal cardiac output decreases with age, primarily due to a presumably linear decline in maximal heart rate. As discussed before, this is a physiological change that does not appear to be responsive to training. The HR max of the hard training group decreased just as much as that of the other same age groups (FT and UT). The decline in maximal heart rate was more dramatic in the older athletes over the same period (FO). Why this is true is unclear, but does help explain their more significant loss of aerobic capacity. Looking at the three "Young" groups only, it is also worth noting that the rate of decline in max heart rate was less (by almost 50%) than what would be predicted using the standard **220 - age formula**. The data above supports the use of a formula that predicts a lower heart rate decline between age 25 and 50, followed by a more dramatic decline after age 50. This has been previously recommended by some others. There are at least a half dozen formulas for predicting maximal heart rate across age. Clearly they are all estimates. Perhaps one day, I will gather all of these in one place. For now, just pick one you like.

Stroke Volume

The other component of cardiac output is stroke volume. This was not directly measured in this study. However, we can make some estimation of relative changes in stroke volume by looking at **oxygen pulse**, or oxygen consumption/ heart rate. In the data above we see that this index of stroke volume declined most dramatically in the groups that trained the least. The hard training group maintained oxygen pulse at near "young" levels. This makes sense physiologically. It is stroke volume that is increased most in the endurance athlete. Maintained high intensity training would be expected to help maintain a high stroke volume. It would have been interesting to compare resting heart rates then and 20 years later, but this data wasn't reported.

Muscle endurance capacity

Muscle biopsies were taken from the gastrocnemious (calf) muscle of the runners during the follow-up test only. As we would expect, the group with the highest training level had the highest activity of the mitochondrial enzymes citrate synthase and succinate dehydrogenase (two common markers for total mitochondrial volume.) The untrained group was the lowest. This decline in muscle oxidative capacity would also be expected to contribute to the decline in VO2 max. However, it would contribute even more to a decline in lactate threshold. Unfortunately, this component of performance potential was not measured.

Running Economy

One other interesting component of this study was the measurement of physiological responses to a standard submaximal running intensity both in the 70s and 22 years later. All of the younger runners had performed several bouts of treadmill running at different speeds back when they were younger, to examine running economy. Two decades later the higher speeds could not be maintained by all the groups. However, many could still run at 12 km/hour without exceeding their VO2 max. So physiological responses at this running speed were compared then and now on 24 of the 53 subjects. All of the hard training group could maintain this speed. So what you will see below is the response to running at a standard speed of 12 km/hour (or about 8 min mile pace). From this data we will be able to discuss the issue of running economy, aging and training status.

	UT (n=6)		FT (n=8)		HT (n=10)	
Variable	THEN	NOW	THEN	NOW	THEN	NOW
VO_2, l/min	2.65	3.39	2.78	3.10	2.63	2.71
VO_2, ml/min/kg	40.3	41.8	39.5	40.1	39.4	38.5

Ok, here everyone was running at precisely the same speed and under the same conditions. However, the physiological cost of maintaining that speed was quite different among the groups. In the UT group, we see from the last two tables that becoming sedentary has not only decreased their VO2 max, it has also resulted in a loss of running economy. Running at the same fairly slow speed now requires 24% more oxygen! As a result, the sedentary guys were now using 78% of their maximal oxygen consumption to run 8 minute miles, compared to only 54% twenty years before! This is the difference between a leisurely jog and an above lactate threshold, exhausting effort.

What is the cause for the increased energy cost of running? Primarily it is due to weight gain. When we factor out bodyweight as the authors did (VO2/ bodyweight), then running economy still decreased by 4%, a statistically significant change in this study. I have gone one step further. When I scaled bodyweight allometrically to more accurately reflect the actual impact of body size on running cost, then the weight independent difference in economy is even greater, 9%. In contrast, the athletes who have continued training at high levels, experienced almost no change in running economy based on absolute changes in oxygen consumption. If anything, they have become slightly more economical compared to their elite days! So, thanks to both weight gain and some unspecified changes in biomechanics or muscle composition that have occurred over the years, the sedentary guys are now 20% less efficient compared to their hard training buddies! The fitness trained (FT) guys also have maintained better running economy than the untrained, but not as good as those who have maintained high levels of training. Once again, they are stuck in the middle of the pack.

Summary

This study substantially supports the findings of several other shorter term longitudinal studies of masters athletes as well as several good cross sectional studies. The main point is of course, **a continued high level of training can significantly reduce the magnitude of VO2 decline that inevitably occurs with aging.** Previously, a 9-10% decline in maximal oxygen consumption/decade has been suggested from studies of untrained healthy men. As suggested by other studies, the results above suggest that the rate of decline is halved (5% /decade and in some cases even less) in athletes who maintain a very high level of training volume and intensity. As we have discussed before. Continued training can maintain stroke volume at high levels, as well as skeletal muscle endurance capacity. Maximal heart rate decline with age, on the other hand, is not altered by activity level.

Lactate threshold intensity was not determined in this study. However, previous investigations have concluded that LT can be maintained if training intensity and volume are maintained.

The third component of the "BIG THREE" endurance performance components that I have discussed on the MAPP is performance efficiency. The results of Dr. Costill and colleagues' study suggest that running economy is maintained (at least at training speeds or below) if weight gain is avoided and training volume is maintained at high levels. In contrast, even when former elite distance runners stop running, they become less efficient runners. These data support the notion that some aspects of running economy are not in-born, but respond to training!