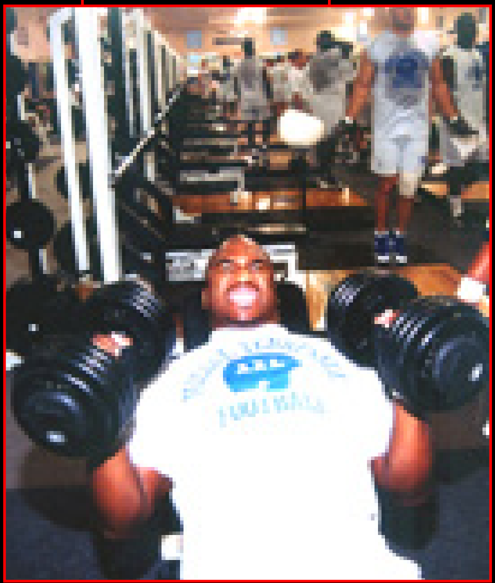
GO TO TOC

SETS 'N' REPS

Finding the optimal strength training dose



KEEP YOUR TRAINING TO FAILURE MINIMAL AND PERFORM MULTIPLE SETS FOR MAXIMAL GAINS

Original Research
Peterson, M.D., et al. Applications of the dose-response for muscular strength development: A review of meta-analytic efficacy and reliability for designing training prescription. *Journal of Strength and Conditioning Research* 19(4):950-958, 2005.

Power Key: sets, intensity, meta-analysis, volume

Every person you ask will give you an opinion about the best number of sets and reps for maximal gains. How do you make sense of all those opinions? Science! When you design your program you have to decide how many sets to do, how many reps, how often to hit the gym, and a plethora of other factors. The optimal combination of all these factors will also depend upon things such as how much training you already have under your belt. While a lot of studies have been done on training programs, most only compare a couple of types. These studies do not always give you enough information on which to base a good training program. Most of them compare single to multiple sets, with conflicting results. There are also a lot of reviews of strength training research out there, but these are subject to the bias of the authors writing the reviews. Mark Peterson, a doctoral student at Arizona State University, and his colleagues decided to examine the existing research in a more formal and objective way. In 2003 and 2004 a couple of meta-analyses were done with up to 200 studies.[1, 2] Peterson consolidated the results to get a better picture of how strength gains are affected as you vary volume, intensity, and frequency. Here are the answers...

NEED POWER?

In a recent issue of the *Journal of Strength and Conditioning Research*, Peterson and his colleagues reviewed the results of these two meta-analyses and also addressed recent criticisms of the papers. They found that in *untrained* individuals, maximal strength gains were achieved by a training intensity of 60% 1-rep max, a frequency of three days per week, and four sets per muscle group. In *recreationally trained* subjects, the optimal combination was 80% 1-rep max, two days per week, and four sets per muscle group. For *athletes*, the optimal combination was 85% 1-rep max, two days per week, and eight sets per muscle group. Keep in mind that these are all averages over time. This means that, if you're an athlete, you can vary the intensity of your training from day to day, as long as over the entire training period the intensity averages out to 85% 1-rep max. In addition, the set volume refers to sets per muscle group. Thus, 3 sets of a flat bench press and 3 sets of an incline bench press would be considered 6 sets for the prime movers (pecs and triceps) in these exercises. Training frequency refers to the number of days per week that each muscle group was trained.

This review clearly shows that multiple sets are superior to single sets. It also supports the idea of a dose-response continuum, where more sets are better to a point, but then the law of diminishing returns sets in and additional sets can cause a reduction in gains (for more, see *Everything in Moderation*). Proponents of single-set training have claimed that the law of diminishing returns applies to any sets beyond the first set, thinking that 90% of all gains comes from the first set. However, this review showed that only 50% of strength-gain potential is achieved by doing one set in untrained and recreationally trained subjects; in athletes, this figure decreases further to 26%.

Your optimal training combination is 85% 1-rep max, two days per week, and eight sets per muscle group.

This review also confirms that beginners make more rapid progress while training at a lower intensity than experienced trainees or athletes, and that athletes need the greatest "dose" (i.e., greatest volume and intensity) to achieve optimal gains. However, athletes also need a bit more recovery (lower training frequency) due to the increased intensity.

Proponents of single-set training advocate training to failure on a regular basis. The researchers examined this contention by taking a subset of 75 studies and comparing the strength gains between training to failure and not training to failure. When the training volume was either 3, 4, or 6 sets per muscle group (there was no comparison data for other set volumes), not training to failure resulted in nearly twice as much gains as training to failure.

GET POWER!

The primary limitation of both of these meta-analyses was the way the statistics were handled. The researchers have been criticized for this before, and their response in this review was that there is no one correct way to do a meta-analysis. While that is true, it is also true that there are mediocre ways of conducting a meta-analysis. For each study, the researchers calculated what is called an effect size. The effect size is a special statistic that measures improvement in the experimental groups. The researcher simply averages the effect sizes for one set, two sets, three sets, and so on, and then compares the averages; four sets showed the largest average effect size for untrained and recreationally trained lifters. But there are a lot of problems with this procedure. First, it does not take into account differences between studies. For example, let's say that in one study, 4 sets were used, the training program lasted 16 weeks, and the effect size was 1.0. In another study, 2 sets were used, the training program lasted 10 weeks, and the effect size was 0.5. It is possible that the effect size in the latter example was smaller because the training program was shorter, not because fewer sets were used. The researchers argued that this is not a major issue because of the extremely large sample of studies they had; they felt that the differences in studies would even out the results. We believe that it is possible that they might not even out, and so the differences between studies may not be due to the number of sets. In other meta-analyses, scientists control for these unknown differences using a special statistical method called a random effects model; however, the Arizona State researchers did not use this model in their meta-analyses.

Another limitation is that the researchers did not account for sample size in the studies. When you do a meta-analysis, studies with a lot of subjects should get more weight than studies with a small number of subjects. This weighting was not done; a study with only 10 subjects got the same weight as a study with 100 subjects.

Not training to failure resulted in nearly twice as much gains as training to failure.

A final limitation is that the researchers did not statistically compare the average effect sizes among different numbers of sets. For example, while the average effect size for 4 sets was larger than for 3 sets, the difference may not be statistically significant, meaning that the difference you see is just a matter of chance. The researchers argued that statistical significance is not a very useful measure. However, it is still important because it gives you an idea of the reliability of the differences that you see in the effect sizes. Just because you see a difference in averages does not mean that a difference really exists. A related statistic that helps you determine how confident you can be in the differences is called a confidence interval; the researchers did not calculate any confidence intervals.

Despite these limitations, the results of this study give you a good starting point from which to design a training program with little doubt that the more advanced a lifter you are, the more and heavier you need to train-up to a point, and that training to failure seems counterproductive for everyone. But remember that this conclusion is based on averages. You certainly may stray from this recommendation for short periods; just make sure that your averages over time, such as an entire training cycle, match up.

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STRETCH WARS

Dynamic vs. static before exercise: Which will win?

LEG EXTENSION POWER IS CRITICAL TO ALL STRENGTH AND POWER SPORTS; DON'T LET STRETCHING ZAP THE POWER.

Original Research
Yamaguchi, T., and K. Ishii. Effects of static stretching for 30 seconds and dynamic stretching on leg extension power. *Journal of Strength and Conditioning Research* 19(3):677-683, 2005.

You know how important it is to warm up before training and competition. You know that a warm muscle is a stronger muscle, a more powerful muscle, and a muscle that is more resistant to injury. Maybe you stretch as part of your warm-up routine. Or maybe you do not stretch because you heard about the flurry of recent research (see *Stretch Longer, Jump Lower* in this issue of **JOPP**) showing that static stretching before exercise might decrease how high you can jump, how much you can lift, how fast you can run, or how well you perform any other activity requiring strength and power. So we know that static stretching might not be the best thing, but there are other ways to stretch instead of just stretching and holding it. In this study, leg extension power was measured before and after three conditions: no stretching, static stretching for 30 seconds, and dynamic stretching (stretches involving movement of the target muscles). No differences were observed between the static stretching and no-stretch conditions. However, leg extension power was significantly higher after dynamic stretching than after no stretching. This study indicates that dynamic stretching may enhance muscle power.

Power Key: stretching, leg extension, power

GO TO TOC

NEED POWER?

Scientists at Hokkaido University in Sapporo, Japan, recruited eleven healthy male college students of an average age of 22.8 years and a weight of 145 pounds (65.9 kg). The men were physically active and had done some weight training in the past, but were not weight training at the time the study was carried out. The researchers measured leg extension power on a special machine where the subjects sat in a seat and extended their legs (see image) by pushing on a footplate as quickly and powerfully as possible. Power was measured five times with rest periods of 15 seconds between trials. The researchers averaged the highest two values as the measure of leg extension power. Leg extension power was measured before and after the three conditions: no stretching, static stretching, or dynamic stretching.

Static stretching involved a stretch for each of the five major muscle groups of the legs (plantar flexors, hip extensors, hamstrings, hip flexors, and quadriceps). A researcher aided each subject during the stretch by stretching the target muscle until the subject verbally asked the researcher to stop the stretch. The stretch was held for 30 seconds. After a 20-second rest period, the other limb was stretched in the same fashion. As with static stretching, a dynamic stretch was done for each of the five major leg muscle groups. This involved the subject contracting and relaxing the antagonist of the target muscle group (such as contracting the hamstrings if the quadriceps were being stretched). This was done every two seconds so that the target muscle was stretched. For example, if the quadriceps were being stretched, the subject rapidly flexed the knee and "kicked" his buttock while standing. These stretches were performed five times slowly, followed by 10 times as quickly as possible without bouncing. These stretches were first done on the left leg and, after 20 seconds' rest, on the right leg. For the nonstretching condition, the subject rested in a sitting position with both legs extended.

Leg extension power did not significantly change in either the static stretch or no-stretch groups. However, certain subjects did experience a decrease in power in these conditions; primarily the subjects with the highest initial leg power were the ones that experienced a decrease. Power significantly increased in the dynamic stretch group from 1,838 watts to 2,022 watts.

GET POWER!

Unlike past studies, static stretching did not decrease leg power, at least on average. However, it did decrease leg power in some subjects, and none of the subjects experienced an increase. The decrease in leg power tended to happen in the subjects who had the highest leg power to start with; this means that static stretching definitely is not good for athletes. Therefore, this study represents another nail in the coffin for static stretching before exercise.

There is just no good evidence that static stretching improves performance; in fact, the evidence indicates the opposite.

Dynamic stretching, on the other hand, improved muscular power. This study was one of the first to look at the effects of dynamic stretching on performance. The researchers did not know why dynamic stretching improved power, but it may have acted as a warm-up for the muscles. That brings out a key limitation in this study. It cannot be determined whether the improvement in power was due to simply a warm-up effect or to the dynamic stretching itself. This study could have been improved if there had been a warm-up condition that did not involve stretching. Another limitation is that recreational and not competitive athletes were used; results may be different for competitive athletes. However, given the findings of this study and others, if you are doing static stretching as a part of your warm-up, you'd be better off doing it at some other time, such as after exercise. Also, although more research is necessary, you might want to consider adding some dynamic stretches to your warm-up routine.

GO TO TOC

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RIBOSE RUBBISH

You get no ergogenic benefit from this supplement

RIBOSE WON'T IMPROVE YOUR HIGH-INTENSITY "WORK" CAPACITY.

Original Research
Kerksick, C., et al. Effects of ribose supplementation prior to and during intense exercise on anaerobic capacity and metabolic markers *International Journal of Sport Nutrition and Exercise Metabolism* 15(6):653-664, 2005.

Athletes are always on the lookout for an extra edge. They can therefore be easily taken in by the hype surrounding popular supplements that are supposed to provide that edge. While some supplements enjoy scientific support, others do not. Ribose is one of those popular supplements that is supposed to improve high-intensity exercise performance by enhancing adenosine triphosphate (ATP) levels in muscle (ATP is the primary fuel source for muscle cells). This study looked at the effects of ribose supplementation on performance of five 30-second cycle sprints and on markers of anaerobic exercise metabolism. Ribose supplementation had no effect on sprint performance or markers of anaerobic metabolism. This is the newest of many studies that have failed to support the supplement industry's contention that ribose will increase your strength and power.

Power Key: ribose, ATP, Wingate test, ammonia, sports performance

NEED POWER?

Ribose is a sugar that is the backbone of ATP, the primary fuel for all muscle cells. Thus, ribose is critical for the creation of ATP in muscle. Ribose proponents believe that by supplementing with ribose you may increase ribose levels in muscle and thus enhance the creation of new ATP. This, they say, would supply more quick energy to the muscle, improve recovery between repeated bouts of high-intensity exercise, and, in turn, improve high-intensity exercise performance via bigger and stronger muscles.

Researchers from the Department of Health, Human Performance and Recreation at Baylor University in Waco, Texas, looked at the effects of ribose supplementation on anaerobic exercise capacity and markers of anaerobic exercise metabolism. Twelve moderately trained male cyclists with an average age of 22.3 years participated in the study. After an eight-hour overnight fast, subjects ingested 150 milliliters of either a placebo drink or a ribose-supplemented drink containing three grams of ribose. The subjects then rested for 25 minutes. The subjects then performed three 30-second Wingate anaerobic capacity tests on a stationary cycle ergometer, separated by three minutes of passive rest. A Wingate test involves a 30-second all-out sprint where peak power, average power, and rate of fatigue are measured. After the first three sprints, the subjects were given another dose of the supplement, and they again rested for 25 minutes. Two more Wingate tests were then performed.

The researchers took blood samples before and after the tests, looking at markers of anaerobic exercise metabolism including blood lactate, glucose (sugar), and ammonia. The study was double-blind, meaning that neither the researchers nor the subjects knew who was receiving the supplement and who was receiving the placebo. In addition, the study was a crossover design, meaning that all subjects received both treatments at different times. In other words, a week later the subjects receiving ribose were given the placebo, and the subjects receiving placebo were given ribose, and then they were re-tested. This is a strong study design, since each subject acted as his own control. When the final results were tallied, there were no differences between the ribose and placebo conditions in peak power, total work, average power, time to peak power, rate of fatigue, or any of the markers of anaerobic metabolism.

GET POWER!

The researchers predicted that if ribose supplementation improved ATP availability, then there would be an increase in peak power after the first or fourth sprints, that average power and total work would be higher, and that ammonia (a breakdown product of ATP) would be lower. However, none of this happened.

This is not the first study to fail to show any ergogenic effect of ribose supplementation. In fact, a large number of studies, involving between 8 and 50 grams of ribose supplementation per day for 3 to 6 days, have not shown any effect of supplementation on various forms of high-intensity exercise (between 6 and 15 sprints of 10 to 30 seconds with 1 to 2 minutes' recovery). These studies also have not shown any effects on markers of anaerobic metabolism, including lactate, ammonia, and ATP.

These results aren't surprising. The rationale behind ribose supplementation is shaky. ATP levels in muscle are not much to sweat about. While ATP levels in muscle can decrease by up to 20% during periods of hard training, these small changes don't affect muscle performance.[1] In fact, a study on isolated muscle fibers showed that they can maintain their maximal contraction speed and strength even when ATP has decreased by 80 to 90%.[2] So ribose simply does not live up to its hype and you are better off spending your money on food.

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BIG MUSCLE, BIG HEART

The female athlete's heart is bigger than the "normal" woman's

You shouldn't be surprised to learn that *every* system in your body is affected by the sport you train and compete in. And yes, your heart is one of those systems. The scientific term used to describe this phenomenon is cardiac remodeling. A number of studies have investigated and described this event, yet most were limited to male athletes, with very little information to be gleaned for the female athlete. To remedy this imbalance, Italian researchers used the extensive database from the National Institute of Sports Medicine in Rome to literally see the effects of cardiac remodeling on elite female athletes of 27 different Olympic sports, ranging from cycling, cross-country skiing, and rowing to shooting, weightlifting, and wrestling. Incredibly, women athletes have "larger" hearts than non-athletes, yet do not show symptoms of disease often associated with enlarged heart muscle.

Original Research
Pelliccia, A., and F. DiPaolo. Cardiac remodeling in women athletes and implications for cardiovascular screening: Position statement of the International Olympic Committee Medical Commission. *Medicine and Science in Sports and Exercise* 37(8):1436-1439, 2005.

Power Key: female athletes, heart, cardiovascular screening

GO TO TOC

NEED POWER?

One of the efforts of the National Institute of Sports Medicine is to collect data on the hearts of elite athletes in Italy. This is done via echocardiography, which uses ultrasound to look at the structure and motion of the heart and vessels, usually in the diagnosis of cardiovascular lesions. The researchers were able to look at a huge sample of 600 female athletes and compare them to their male counterparts and sedentary women. About one-third of the women had competed internationally and at the Olympics.

Size matters

The left ventricle (LV) is the lower chamber on the left side of the heart that receives arterial blood from the left atrium, situated above the ventricle, and then ejects the blood via contraction into the aorta, from which the blood is delivered to the arteries of the body. It does not take much imagination to see that athletic events would require stronger contractions of the LV to supply the rest of the exercising body with its "lifeblood." And indeed, this effort causes a marked increase in LV chamber size. Normal upper limits are around 54 mm and about 8% of the athletes showed enlargements greater than 60 mm. The upper limit of LV wall thickness is set at 12 mm and none of the women's hearts exceeded that limit. Interestingly, the relative wall thickness ranged widely among the athletes, and the total mass of the LV was above the accepted normal limits in 6% of athletes.

When compared to sedentary female controls of similar age, body size, and racial composition, athletes showed an increased LV cavity of 6%, increased wall thickness by 14%, increased average wall thickness of 9%, and increased LV mass of 25%. Despite these marked differences in the heart, none of the athletes showed any alterations in systolic function of the heart (systolic refers to the contraction of the ventricle and ejection of blood from the heart). Diastolic action of the heart (when blood fills its chambers) was assessed via Doppler echocardiography and showed normal function as well.

Comparisons to 738 male athletes of similar age, sports, and ethnic origin showed that the women's hearts were smaller in every respect. To illustrate, LV cavity dimension was 11% smaller, maximum wall thickness 23% smaller, relative wall thickness 9% smaller, and mass less by 31%.

GET POWER!

Further statistical analysis of the data revealed that the changes in heart dimensions were associated with body size, older chronological age, and lower resting heart rate. This lower resting heart rate is directly related to the intensity and duration of the athletic endeavor. Consequently, endurance sports had the greatest degree of change in LV cavity dimensions. Other sports, such as team ball sports, track and field, and gymnastics, were correlated with moderate changes, while sports such as weightlifting and wrestling had only minimal effects.

So the female athlete, just like the male athlete, has a larger heart than the non-athlete. So what? The main reason that we have shared this information with you is because it relates to the diagnosis of heart disease. Quite simply, the enlarged heart of the athlete can result in a diagnosis of heart disease or structural cardiovascular disease. Indeed, the structural difference in the hearts of the female athletes can reach into and beyond the pathologic range of people with dilated cardiomyopathy (a heart disease with an unknown cause). A doctor could therefore mistakenly diagnose an athlete's enlarged heart as a medical condition requiring drugs and other unnecessary treatment, including a recommendation to stop practicing the sport.

The main criticism that we see with this study is that it only represents Italian elite athletes. In many different geographical areas, different ethnic populations show differences in various bodily systems. It is therefore not a given that the same sort of results would be found in other European nations, Africa, Asia, North America, etc. We feel that the International Olympic Committee would be well advised to obtain additional data around the world on cardiac remodeling in both male and female athletes. In addition, it would be beneficial to know at what point of athletic proficiency an athlete would not show these gains in heart size.

GO TO TOC

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KID'S ENERGY

Knowing your energy expenditure is critical for sports success-and you can't go by what the adults do

FEED THE KID! CHILDREN WILL EXPEND MORE ENERGY FOR THE SAME TASK AS AN ADULT.

Original Research
Harrell, J., et al. Energy costs of physical activities in children and adolescents. *Medicine and Science in Sports and Exercise* 37(2):329-336, 2005.

Obviously, your training is the most critical component of your sporting success. But immediately after what you do in training comes nutrition. The simple fact is that without training you will not improve. But if you do not know how much energy your activity consumes, how can you refuel your body properly? Since the 1990s adults have had an opportunity to review how much energy different activities require, thereby gaining accurate information to use in planning an effective nutritional regimen, exercise intensity, etc. However, the same does not hold true for children and teenagers. In fact, coaches and parents typically design kids' diet and exercise regimens based on knowledge derived for adults. As this study will show, that could prove to be a mistake.

Power Key: energy use, children, youth, adolescents, exercise

GO TO TOC

NEED POWER?

On one hand it seems so obvious: a child is not an adult. But in the realm of sport what is so incredibly obvious gets lost in all the media hype, misrepresentations of research, and of course the deep desire to provide a child athlete with the utmost opportunity to excel. So most of what a child athlete is exposed to is coaching based on adult success formulas. Problem is, if you end up forgetting the obvious fact that a child is not an adult, the time, effort, and money spent on training might prove counterproductive.

To illustrate, past research has shown that a child's resting energy expenditure is higher than an adult's. And in children in puberty, it is usually higher than in prepubertal children. And in boys it is higher than in girls. The reason involves any number of factors ranging from growth and puberty to differences in body mass and children's relatively larger organs compared to an adult's. But this is just at rest. What do we know about kids "at work"? Sadly, not enough. In most of the studies, the sample sizes were too small to make meaningful generalizations, girls were left out, and no effort was made to determine at what age a child would take on an energy expenditure value similar to an adult's. This study sought to answer these questions.

Scientists from the Department of Exercise and Sports Science at the University of North Carolina and the College of Nursing at the University of Utah collaborated in an effort to establish the energy expenditure of physical activity in youth. They studied 295 subjects ranging in age between 8 and 18; 53% were males and 47% females; 75.6% were white, 15.6% black, and 8.8% of another race. The subjects had only to be healthy and have no limitations on exercise. They were recruited via advertisements in local newspapers, flyers at local schools, and mass e-mails, and the study was conducted in the applied physiology laboratory on the Chapel Hill campus at North Carolina. Energy expenditure was measured with a portable metabolic system that can measure breath-by-breath ventilation, expired oxygen, and carbon dioxide. This lightweight system attaches via a mask to the subject's face, allowing for full mobility during many different exercises. In addition, body height and mass were assessed, along with an estimation of each subject's stage of puberty using the Pubertal Development Scale. The activities that were studied included reading, sitting, walking at 2.5 and 3.5 mph, shoveling, stretching, vacuuming, bench and leg pressing, stair climbing, sweeping, running at 5 mph, and rope skipping. Each subject was tested three times and each time testing began with some of the sedentary activities and graduated to more physically demanding ones, with each activity lasting 10 minutes.

The Energy Factor

Pubertal differences in age for resting energy expenditure was significant for VO_2 in boys and girls. For the boys, the significant age differences were broken down in categories ranging from 8 to 12 (age group 1), 13 to 15 (age group 2), and 16 to 18 (age group 3). For the girls the age ranges were 8 to 11 (age group 1), 12 to 14 (age group 2), and 15 to 18 (age group 3). These differences between boys and girls are consistent with other research that has found girls to enter and exit puberty sooner than boys. The pubertal status of the subjects ranged widely, with 21% at Tanner Stage 1, 14.2% at Tanner Stage 2, 20% at Tanner Stage 3, 30.5% at Tanner Stage 4, and 14.2% at Tanner Stage 5. [Click here for more.]

Resting oxygen uptake did not differ between boys and girls, but it did decrease as the ages of the groups increased. The data analysis also revealed that all the subjects had higher energy expenditures at rest than adults. Similarly, the younger the child, the higher the resting energy expenditure.

The analysis of data for the activities showed that there were no significant differences between boys and girls. However, some small differences were recorded in VO_2 by gender in the leg press, rope skipping, shoveling, and stretching in age groups 2 and 3. But since these differences were small and nonsignificant, there is no need to view energy expenditures during exercise as different to any meaningful extent between boys and girls. For the higher intensity activities there was more variability between the age categories. As an example, for rope skipping and running, the values were lower for the youngest age group, yet similar for the other two age groups.

This research highlights two conclusions: 1) resting energy expenditure in children is greater than in adults; 2) depending on the child's stage of development, both resting and activity-based energy expenditure varies, approaching that of an adult by the fifth Tanner stage, meaning that generally the younger child will expend more energy than the older for the same activity. Another important consideration lies in the math component. As an example, this research found that if you were to use an adult's energy expenditure values for a 9-year old who weighs 77 pounds over a typical day of activity, the adult values would underestimate the actual energy expenditure by almost 1,000 calories or about 42%. So this study was also able to come up with accurate math to determine a child's energy expenditure.

GET POWER!

This study does a great job of shedding light on the difference in energy expenditure during rest and activity in children as compared to adults. This is critically important when assessing a child's physical activity, recommending diet and exercise guidelines, and of course developing future research projects. The researchers still recognize, however, that although the computations they derived improve the precision of energy expenditure estimates greatly, they are still not ideal. In addition, although this study looks at a number of activities done by children, it is not comprehensive (for adults, the list includes over 600 activities). In other words, if you are interested in a child's energy expenditure in the weight room vs. the playing field, it would still be quite difficult for you to arrive at an exact value.

A child will expend more energy than an adult for an equal activity; not until later in puberty will the energy expenditure start to equal that of an adult.

Another limitation is that this study did not use sufficient numbers of boys and girls to ascertain gender differences to a meaningful extent. Though this study found no differences, that result might be simply because there were not enough subjects in each gender category. And finally, if you are a coach or parent, your ability to compute a child's energy expenditure is still fairly complex. You would have to seek out the activity from the adult compendium of energy expenditures and multiply those factors by the ones in this study, which means you would need to obtain a copy of this study along with its tables and let an exercise scientist derive the numbers for you. Admittedly, not ideal. Nevertheless, the most important message you should take home from the review of this study is that child athletes will likely expend a great deal more energy in sporting activities than an adult.

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PUTTING THE HEAT ON

Do neoprene sleeves increase heat in muscle?

BEEN RESTING A WHILE? NOW IT'S TIME TO CRANK? A NEOPRENE SLEEVE WILL KEEP YOUR TISSUES WARM BUT WILL NOT PROVIDE ADDITIONAL BENEFITS.

Original Research
Miller, A., et al. Neoprene thigh sleeves and muscle cooling after exercise. *Journal of Athletic Training* 40(4):264-270, 2005.

Unfortunately, if you are injured you just might have to train through your injury. If this is the case, you might wear a neoprene sleeve to provide extra warmth for the injured muscle and joint in hopes that this will allow the tissue to better handle the demands of the activity and decrease the risk of further injury. However, no research has ever been done to see if neoprene sleeves really do increase heat in muscle. In this study, subjects engaged in different intensities of cycling exercise with and without wearing a neoprene sleeve. Neoprene sleeves increased skin temperature, but did not affect muscle temperature before and during exercise. Post-exercise muscle temperature was 1 to 2°F higher when the sleeve was worn. Thus, neoprene sleeves prevent muscle from cooling rather than enhancing tissue heat. Wearing neoprene sleeves will help you keep an injured muscle warm during recovery periods between bouts of exercise (such as when you're resting between plays or periods during a football game or soccer match).

Power Key: neoprene sleeve, intramuscular temperature

GO TO TOC

NEED POWER?

Athletes and coaches use a neoprene sleeve because they believe that it will increase muscle temperature, allow the tissue to better handle the demands of activity, and decrease the risk of injury (because warm tissue is more pliable and less likely to tear). While exercise alone will also increase muscle temperature (which is why you warm up, or at least *should*), a neoprene sleeve may enhance this effect. Despite this common belief, no research has ever been done to see if this is really true.

Alison Miller, an athletic trainer at Loara High School in Anaheim, California, got together with her colleagues at Brigham Young University in Provo, Utah, to determine the effects of a neoprene sleeve on skin and muscle temperature during exercise. Subjects were 12 male (average age of 23 years) and 12 female (average age of 21 years) NCAA Division I collegiate athletes who were participating in an off-season strength and conditioning program. Subjects engaged in three exercise conditions: control (no exercise), 50% of maximum heart rate, and 70% of maximum heart rate. There was a minimum of 24 to 72 hours' rest between sessions. Each treatment was performed with the neoprene sleeve on one leg, while the opposite leg served as a control. Exercise was performed on a cycle ergometer for 15 minutes. Skin and muscle temperatures were measured using special thermometers placed on the skin and embedded in the muscle. Temperature samples were taken every 10 seconds for 50 minutes of the one-hour experiment. The subjects rested 15 minutes before exercise, with temperature readings beginning the last five minutes of that period. After 15 minutes of exercise, subjects rested for an additional 30 minutes. Heart rate was measured using a heart rate monitor.

Tallying the Results

Wearing the sleeve resulted in higher skin temperatures for both males and females as opposed to not wearing the sleeve. On average, skin temperatures were about 2°F higher in the control condition, 4°F higher in the 50% maximum heart rate condition, and 5°F higher in the 70% maximum heart rate condition.

In the control condition, the response of intramuscular temperatures to the sleeve differed among males and females. The sleeve resulted in higher intramuscular temperatures in the females, but not the males. During both exercise conditions, the sleeve did not significantly increase intramuscular temperature in either males or females. However, after exercise, intramuscular temperature was significantly elevated for 30 minutes in both males and females when the sleeve was worn. On average, the sleeve elevated post-exercise muscle temperature by 1 to 2°F.

GET POWER!

The primary conclusion of this study is that neoprene sleeves do not enhance muscle tissue heat; rather, they prevent the tissue from cooling. This can be important for activities in which the exercise is intermittent. For example, a football player will be out on the field for some plays and then will sit on the sideline. Basketball players are often taken out of a game and sit on the bench. In powerlifting and weightlifting, athletes warm up and have to wait until they are up and then again before the subsequent exercise is performed. A neoprene sleeve can help keep your muscle tissue warm when you have to rest for an extended period of time.

The main limitation of this study is that it is not certain whether the 1 to 2°F elevation in post-exercise muscle temperature is sufficient to increase muscle pliability and help prevent injury. Regardless, any elevation in muscle temperature is better than none, so it is a good idea for athletes who are nursing injuries or just trying to stay warm to wear neoprene sleeves to keep muscles warm. Another limitation is that only one type of neoprene sleeve was used. Other brands may have different results. Finally, the exercise time was 15 minutes. It is not clear how results would differ for exercise of shorter or longer durations.

Regardless of these limitations, a neoprene sleeve will increase skin temperature, not muscle temperature, as many people believe. But bear in mind that elevated skin temperature will not prevent injury and that raised muscle temperature is what really counts. So if you use a neoprene sleeve simply to keep your tissue warm while you rest between attempts or matches, you have placed it in the right context of what it can do for you without hype and unrealistic expectations.