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Why Self-Regulation Strategies?

The prior issue detailed goal setting, planning, tracking and monitoring, and other self-regulation strategies. A number of examples showed how well these strategies fit with progressive resistance and cardiovascular training.

However, realistically, most advanced trainees will not experience a great deal of progress relative to prior performances. Examples were used in the last and other recent issues to show that progress will likely be selective, or represent training hard to reach levels previously reached, or attaining good training performances based on age considerations.

"Training can be organized to create optimal experiences."

If progress is modest, selective, or primarily relevant within an age context, why go through all the self-regulation steps?

One answer to this question is that it keeps your training honest in a number of ways. For example, record keeping for resistance training should include notes about your form. A specific performance (resistance, repetitions, time under load) only would count if your form remained constant and as perfect as you possibly could execute repetitions. Record keeping also allows you to exactly see your level of fitness. Rather than saying 'I'm still in pretty good shape' or 'I'm just as fit as ever', you will know precisely where you are compared to previous years or certain external standards.

There is a more profound answer to the question. The answer revolves around optimal experiences, enjoyment, and meaning in your life.

Research in 'positive psychology' has studied what kinds of behaviors and situations are associated with happiness. Are those behaviors and situations watching a great sporting event or Broadway play, getting a long-deserved raise, drinking a fine wine, or eating your favorite foods? These types of behaviors and situations can certainly bring some pleasure but are not the behaviors and situations that people report as their happiest. In fact, those pleasures are quickly forgotten and are habituated to quite easily. Your first few bites of a gourmet meal or the first couple of sips of fine wine may quickly both satisfy and habituate your taste buds. You only may remember a few days later that the food and wine were 'really great'.

Notice also that for some behaviors and situations associated in our culture with pleasure and fun, people are essentially passive. After all, the person watching the football game did not throw the winning touchdown pass and the person enjoying the gourmet meal was not the chef who created the meal.

The passive-active dimension is important. People report being most happy when they focus their attention and are active and engaged not when they are passive.

The behaviors and situations that are gauged as optimal experiences and where the highest levels of happiness are reported across different cultures have several key qualities. These behaviors and situations revolve around your planned activities that are a good match for your skills and talents. You are very engaged in the activities. These behaviors and situations involve some challenge and hard but reachable goals. You also receive a good deal of feedback, typically, simply as part of your engagement, about how well you are performing your activities and meeting your goals.

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tant strategies. Just remember not to get so fixated on the amount of resistance you are actually using. The amount of resistance is entirely relative to a specific performance style, time under load, exercise order, and type of machine.

If resistance is relative, your training approach can become more intrinsic. You should focus your attention on your performance of every repetition and the effects the exercise is having on the targeted muscle groups. The effects on the targeted muscle groups when an exercise is performed correctly should be profound. With each repetition you can receive feedback about just how focused you are and how effective you are. If the experience is not optimal, within the workout or in the next workout you can make changes to improve your training and in the process optimize the flow experiences of training.

Here is one suggestion. Perhaps you have already tried this approach, perhaps not. Instead of changing exercises, their order, or your routine, just make it a point to focus more on each repetition and the response in a muscle group. That's already been noted in this and other articles. The question is 'How do you train that way?' The simplest way is to make the duration of each of your repetitions longer, do very smooth turnarounds in the positive and negative part of each repetition, and do the largest range of motion that is still comfortable for you. If you have been taking about three seconds for the positive part of the repetition and three seconds for the negative part, move to four-seconds positive, one-second pause, four-seconds negative duration repetition. If you are already performing 4,1,4 repetitions, try 8,1,4 repetitions. If you are performing 8,1,4 repetitions, try 10,1,5.

Using longer duration repetitions won't make you magically stronger or grew lots of new muscle mass. In fact, quite consistent with this piece, assuming a similar or longer time under load for a set, you will likely use less resistance than in your prior workouts. This shows that resistance is relative to performance mode. Training in this more focused way does demand directing a great deal of attention to the task at hand. As suggested in this issue, directing your attention to optimally perform planned, goal-directed activities that provide lots of feedback makes the experience intrinsically rewarding. There's great motivation to continue to train at a high level because the process is so enjoyable. ◆

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Glucosamine and Chondroitin: What the Research Says

By Matt Brzycki, Princeton University

Also referred to as "degenerative joint disease," osteoarthritis is the most common type of arthritis. In fact, it's estimated that 20 million American adults have osteoarthritis – and that number is expected to double over the next 20 years. The disease is caused by the breakdown of cartilage (the connective tissue that cushions the ends of the bones that are within a joint) and is characterized by pain, stiffness and limited function. In general, osteoarthritis usually affects the hips, knees and hands. And as older readers are painfully aware, aging is a risk factor for this condition.

Glucosamine and chondroitin are natural substances that are found in cartilage. It's believed that glucosamine – a combination of glucose (a sugar) and glutamine (an amino acid) – inhibits inflammation and stimulates the growth of cartilage while chondroitin gives cartilage strength and resilience. As a result, these two substances have been promoted as viable treatments for osteoarthritis. And since osteoarthritis affects so many Americans, it's little surprise that glucosamine and chondroitin are among the most popular dietary supplements in this country with an estimated $730 million in sales in 2004.

The Research

Of course, anecdotal reports are one thing and scientific studies are another. Let's take a look at some of the randomized, double-blind, placebo-controlled studies and meta-analyses on the safety and efficacy of glucosamine and chondroitin in the treatment of osteoarthritis.

McAlindon and Co-Workers[1]

In this meta-analysis, the researchers examined the quality of the studies on glucosamine and chondroitin that were published or performed prior to 1998. To be included in their meta-analysis, a study had to be of at least four weeks in duration that looked at knee and hip osteoarthritis and reported extractable data on the effect of the treatment on symptoms. The researchers found 15 studies that met their inclusion criteria.

One of the important findings of this meta-analysis was that 13 of the 15 studies were financially supported by a manufacturer, performed by a manufacturer or had at least one author who was affiliated with a manufacturer. There was only one study that was conducted by independent researchers. (In the other study, the researchers who performed the meta-analysis were unable to determine whether or not a manufacturer was involved.)

In addition, the researchers found strong evidence of publication bias. This is the greater likelihood that research with statistically significant results will be published compared to research with statistically non-significant results. In other words, there was evidence of selective publication of studies that found positive effects from the use of glucosamine and chondroitin.

In short, the researchers found that the 15 studies exhibited methodological problems and exaggerated the benefits of glucosamine and chondroitin. Nevertheless, the researchers concluded that "it seems probable that [glucosamine and chondriotin] do have some efficacy in treating [osteoarthritis] symptoms and that they are safe."

"How well does glusosamine work?"

Rindone and Co-Workers[2]

This study looked at the effectiveness of glucosamine on reducing pain from knee osteoarthritis. The subjects were recruited by referral from primary care providers in the outpatient clinics of a medical center in Arizona. The 114 subjects who met the inclusion criteria were assigned to receive either 500 milligrams of glucosamine or a placebo (unspecified) three times per day (a total of 1,500 milligrams per day) for two months. Data were analyzed on 98 subjects (aged 34 – 81). Subjects who were taking other analgesics were instructed to continue using them throughout the study.

The subjects were evaluated at Days 0, 30 and 60 in knee pain while resting and walking. After two months, glucosamine was no more effective than a placebo for osteoarthritis of the knee.

A large number of subjects reported side effects: 17 (34%) in the glucosamine group and 11 (23%) in the placebo group. Side effects included loose stools, nausea, heartburn and headache. Because of the side effects, two subjects in the glucosamine group withdrew from the study (diarrhea and dizziness). The side effects subsided after the treatment was stopped. Four subjects in the placebo group withdrew from the study (rash, sedation, diarrhea and constipation).

Reginster and Co-Workers[3]

This study on glucosamine was hailed as a "landmark in osteoarthritis research." In the study, 212 subjects over the age of 50 with knee osteoarthritis were assigned to receive 1,500 milligrams of glucosamine sulphate or a placebo (unspecified) once per day for three years. (After three years, 38 of the 106 subjects in the glucosamine group and 35 of the 106 subjects in the placebo group had withdrawn from the study.) The subjects were allowed to take a rescue medication (paracetamol or non-steroidal anti-inflammatory drugs) – and most of them took at least one dose.

The glucosamine group had no significant joint space narrowing while the placebo group had progressive joint space narrowing. Severity of joint pain, stiffness and limitation of physical function improved in the glucosamine group and worsened slightly in the placebo group.

The researchers stated that there was "no apparent correlation" between the intake of rescue medications and joint space narrowing or symptom outcome. However, no data were presented to substantiate this assertion.

Most of the subjects in both groups reported at least one side effect: 94% with glucosamine and 93% with placebo. (Some subjects reported more than one side effect.) The most prevalent side effects were abdominal pain, increased blood pressure, diarrhea and fatigue.

The study was supported by a research grant from the Rotta Research Group, an Italian pharmaceutical company. In addition, two of the 10 researchers were Rotta employees.

Hughes and Carr[4]

In this study, researchers looked at the effectiveness of glucosamine on managing pain from knee osteoarthritis. Subjects over the age of 40 were recruited from a hospital rheumatology outpatient department. The 80 subjects who met the inclusion criteria were assigned to receive either 500 milligrams of glucosamine sulfate or a placebo (calcium carbonate) three times per day (a total of 1,500 milligrams per day) for six months. Additionally, the subjects were permitted to continue taking their existing non-steroidal anti-inflammatory drugs. The subjects were allowed access to a rescue medication (paracetamol or other prescribed analgesia).

The subjects were tested at Weeks 0, 6, 12 and 24 in knee pain, stiffness and function. With respect to range of motion in knee flexion, the glucosamine group increased by 4.00 degrees and the placebo group decreased by 8.55 degrees. Since these measures were obtained with a goniometer, the difference could be attributed to human error. There were no statistically significant differences between the glucosamine group and the placebo group in any other outcome.

The majority of the subjects in both groups reported at least one side effect: 62.5% with glucosamine and 67.5% with placebo. The most prevalent side effects were increased musculoskeletal pain, cold/flu, headache and constipation.

Health Perception UK – a British company that manufactures glucosamine sulfate and other nutritional supplements – provided all of the medication used in this study.

The company also funded two research nurses who recruited the subjects, performed the assessments and entered all of the outcome data onto a computer.

Pavelka and Co-Workers[5]

This study examined the effects of glucosamine on knee osteoarthritis. In the study, 202 subjects (age 45 – 70) with knee osteoarthritis were assigned to receive 1,500 milligrams of glucosamine sulphate or a placebo (unspecified) once per day for three years. (After three years, 35 of the 101 subjects in the glucosamine group and 46 of the 101 subjects in the placebo group had withdrawn from the study.) The subjects were allowed to take a rescue medication (acetaminophen) as needed and about 30-40% of the subjects in both groups took it an average of at least once every three days. Hydrotherapy, exercise and ultrasound were allowed if a subject was following "a stable regimen." According to the researchers, 22% of the glucosamine group and 27% of the placebo group used these physical treatments.

After three years, the glucosamine group had no joint space narrowing while the placebo group had progressive joint space narrowing. Knee pain and stiffness decreased and function increased in both groups but improvements were significantly greater in the glucosamine group.

Most of the subjects in both groups reported at least one side effect: 66% with glucosamine and 64% with placebo. (Some subjects reported more than one side effect.) The most common side effects were attributable to the gastrointestinal tract and liver (mostly abdominal pain and dyspeptic symptoms), the musculoskeletal system (mostly osteoarthritis-related symptoms or back pain) and the cardiovascular system (mostly increased blood pressure). Reports of urinary tract infections were also common in both groups.

The Rotta Research Group – an Italian pharmaceutical company – funded this study. In addition, two of the six researchers were Rotta employees.

Braham, Dawson and Goodman[6]

In this study, researchers looked at the effects of glucosamine on functional ability and pain. The study involved 46 subjects (age 20 – 70) who suffered "from regular knee pain of unspecified origin." The subjects were assigned to receive either 2,000 milligrams of glucosamine hydrochloride or a placebo (lactose) once per day for 12 weeks. In addition, the subjects were instructed to maintain their current exercise programs and required to document all non-steroidal anti-inflammatory drugs and prescription medicine that they took throughout the duration of the study.

The subjects were tested at Weeks 0, 4, 8 and 12 in joint line palpation of the knees (to measure cartilage pain), a duck walk (for three meters) and a stair climb (32 steps – 16 up and 16 down – without using the handrails and repeated for up to five times or a total of 160 steps). The subjects were also required to complete two questionnaires: the Knee Pain Scale and the Knee Injury and Osteoarthritis Outcome Score.

There were no significant improvements in the joint line palpation, duck walk and stair climb between the two groups. However, the glucosamine group reported significantly less pain than the placebo group after completing a three-meter "duck walk" or "at the best position that they could achieve in the squat." After 12 weeks, 88% of the glucosamine group reported some degree of relief in knee pain compared to 17% of the placebo group.

A total of 15 subjects (33%) experienced some side effects with the glucosamine group reporting 11 and the placebo group reporting 10. (Some subjects reported more than one side effect.) The most prevalent side effects were gastrointestinal upset/cramps, headache and dry mouth.

Musashi – an Australian company that makes sports supplements – furnished the glucosamine that was used in this study.

Richy and Co-Workers[7]

In this meta-analysis, researchers examined the structural and symptomatic efficacy of glucosamine and chondroitin on knee osteoarthritis based upon joint space narrowing. To be included in their meta-analysis, a study had to be of at least four weeks in duration and published or performed between January 1980 and March 2002. The researchers found 15 studies that met their inclusion criteria.

The 15 studies contained data of 1,775 subjects (1,020 for glucosamine and 755 for chondroitin). The researchers rated the quality of the glucosamine studies as significantly better than the chondroitin studies.

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I will try to answer as many questions as possible in future issues.

This meta-analysis found that the structural efficacy of glucosamine sulfate on joint space narrowing is highly significant; the quality of studies wasn't strong enough to assess the effects of chondroitin sulfate on joint space narrowing. Furthermore, the researchers stated, "Our results suggest that the long-term administration of daily oral glucosamine sulfate at the minimal dosage of 1,500 milligrams during a minimal period of three years slows the degenerative process of the joint cartilage." The researchers concluded that "the oral administration of glucosamine and chondroitin decreases the symptoms of osteoarthritis."

Of note is that in all trials, the subjects were allowed to take a rescue medication (such as non-steroidal anti-inflammatory drugs). None of the 15 studies in the meta-analysis showed a rate of side effects that was higher in the treated group compared to the placebo group.

McAlindon and Co-Workers[8]

This Internet-based study examined the safety and efficacy of glucosamine on knee osteoarthritis. The researchers solicited applicants using advertisements and an interactive screening form on their website. Those who passed the screening were asked to supply the researchers with a medical release form in order to obtain their medical records, radiographs or magnetic resonance imaging (MRI) scans. In the study, 205 subjects over the age of 44 received either 1,500 milligrams of glucosamine or a placebo (rice starch) once per day for 12 weeks. (Note: Initially, the researchers purchased glucosamine sulfate and placebo capsules. During the study, the manufacturer declined to supply more placebo capsules. At that point, the researchers used a powder that was sealed in sachets from another manufacturer. The sachets contained either glucosamine hydrochloride or rice powder.)

The researchers found that glucosamine was no more effective than a placebo in relieving pain and stiffness in patients with knee osteoarthritis. Pain ratings decreased in both groups throughout the study. However, there were no significant differences in the change in pain ratings between the glucosamine group and the placebo group. In fact, the placebo group reduced their pain rating by 27.5% while the glucosamine group reduced their pain rating by 22.7%.

There were 18 subjects in the glucosamine group (17.8%) who reported side effects and 14 in the placebo group (13.5%). (Some subjects reported more than one side effect.) The most prevalent side effects were gastrointestinal distress (four glucosamine and six placebo) and arthralgia (five glucosamine and two placebo).

The majority of the subjects used non-steroidal anti-inflammatory drugs (74% of the glucosamine group and 87% of the placebo group). In terms of "acetaminophen equivalents," the glucosamine group increased their use from 1,845 milligrams to 1,978 milligrams while the placebo group decreased their use from 1,309 milligrams to 1,221 milligrams.

One drawback of this study was the heavy reliance upon self-reports to assess adherence. Subjects were asked to report the number of capsules or sachets remaining at the end of each month and to return unused materials by mail.

Poolsup and Co-Workers[9]

In this meta-analysis, researchers examined the structural and symptomatic efficacy of glucosamine on knee osteoarthritis. To be included in their meta-analysis, a study had to be of at least one year in duration and reported symptom severity and disease progression as assessed by joint space narrowing. The researchers found two studies that met their inclusion criteria. These two studies – by Reginster and co-workers[3] and Pavelka and co-workers[5] – have been discussed previously.

Pooled data of the 414 subjects in the two studies showed that in comparison to a placebo, long-term treatment with glucosamine was superior in delaying structural progression of osteoporosis (based upon joint space narrowing) and more effective in reducing pain and improving physical function. The data also showed that short-term treatment with glucosamine (about 6.25 weeks) was more effective than with a placebo in improving pain but not in improving function.

In the two studies, the common side effects reported by those who received glucosamine were abdominal pain, dyspepsia, diarrhea, increased blood pressure, fatigue and rash. However, the incidence of these side effects was the same as those who received a placebo.

Clegg and Co-Workers[10]

This study was conducted at 16 centers across the United States and coordinated by the University of Utah. The long-awaited results of this study – referred to as the Glucosamine/Chondroitin Arthritis Intervention Trial or, more simply, by the acronym "GAIT" – were finally published in February, 2006. GAIT looked at the effects of glucosamine and chondroitin on pain from knee osteo-

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arthritis. The study involved 1,583 subjects over the age of 40 with knee pain and radiographic evidence of osteoarthritis. The subjects were assigned to receive a dose of either (1) 500 milligrams of glucosamine hydrochloride three times per day (a total of 1,500 milligrams per day); (2) 400 milligrams of chondroitin sulfate three times per day (a total of 1,200 milligrams per day); (3) glucosamine and chondroitin in combination; (4) 200 milligrams of celecoxib (brand name Celebrex®) once per day; or (5) a placebo (unspecified) for 24 weeks. (After 24 weeks, 20.5% of the subjects had withdrawn from the study.) The subjects were allowed to use "up to 4,000 milligrams" of acetaminophen as a rescue medication once per day throughout the study (except during the 24 hours prior to being evaluated for knee pain).

The study found that glucosamine and chondroitin – alone or in combination – weren't significantly better than the placebo in reducing knee pain by more than 20%. A sub-group of subjects with mild pain showed even less effects. In a sub-group of patients with moderate-to-severe pain – which included 22% of the subjects in the study – the combination of glucosamine and chondroitin was significantly better than the placebo. But celecoxib, glucosamine and chondroitin weren't significantly better than the placebo.

A total of 61 subjects reported 77 side effects. (Some subjects reported more than one side effect.) Side effects caused 59 subjects to withdraw from the study, including 9 in the glucosamine group (2.8%); 20 in the chondroitin group (6.3%); 12 in the glucosamine-chondroitin group (3.8%); 7 in the celecoxib group (2.2%); and 11 in the placebo group (3.5%). According to the researchers, the side effects were "generally mild." However, three side effects were serious and judged to be related to the treatment: congestive heart failure (in a subject who received glucosamine and chondroitin), stroke (in a subject who received celecoxib) and chest pain (in a subject who received glucosamine). The chondroitin group had the highest incidence of "musculoskeletal and connective-tissue" events and the lowest incidence of vomiting. Compared to the other four groups, the celecoxib group had a higher but non-significant incidence of "cardiac" events (mostly arrhythmias). Compared to the placebo group, the celecoxib group had a significantly lower incidence of headache and nausea and a higher but non-significant incidence of increased blood pressure.

The study was sponsored by the National Institutes of Health and supported by a contract from the National Center for Complementary and Alternative Medicine and the National Institute of Arthritis and Musculoskeletal and Skin Diseases. Ferro Pfanstiehl Laboratories – a company headquartered in America that makes pharmaceutical products – donated a portion of the glucosamine that was used in this study; Bioiberica – a Spanish company that makes joint-care products – donated the chondroitin that was used in this study. Of the 25 co-authors of this study, 12 disclosed some type of tie to a pharmaceutical company. This included receiving consulting fees, serving on an advisory board, having equity interests, receiving lecture fees, getting grant support and serving as an expert consultant.

Conclusion

Most of the studies that have examined the safety and efficacy of glucosamine and chondroitin have been of very short duration (less than about four weeks). In addition, numerous studies on these two substances – particularly those on chondroitin – are of low quality with many having been sponsored in some manner by a product manufacturer. Indeed, the two longest studies (three years in length) were both funded by a pharmaceutical company and had employees from the company listed as co-authors.

It appears that glucosamine prevents joint space narrowing. However, the use of this factor to gauge the severity of osteoarthritis is debatable. Indeed, joint space narrowing may be one of the least important predictors of pain and function. And although some studies have found that glucosamine decreases pain more than a placebo, other studies have not.

Many studies have reported a very high percentage of side effects from glucosamine. In most of the studies, however, the rate of side effects reported by those who used glucosamine wasn't significantly greater than those who used a placebo. The most prevalent side effects were abdominal pain, diarrhea, headaches and increased blood pressure.

Confounding the interpretation of the data is the fact that analgesics and/or non-steroidal anti-inflammatory were allowed during most of the studies. And in terms of quality, glucosamine that's a prescription drug cannot be compared to glucosamine that's a dietary supplement.

Bottom line: Glucosamine and chondroitin appear to be relatively safe and have shown some promise in combating osteoarthritis. But, at this point, the outcomes reported in research on these two substances need to be more convincing to support long-term use.

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Science Department

Will Increasing the Number of Sets in Your Workout Increase Energy Expenditure and Improve Body Composition?

Haddock RL, Wilkin LD. Resistance training volume and post exercise energy expenditure. *International Journal of Sports Medicine*. 2006; *27:* 143-148.

Exercise training can contribute to favorable body composition changes in a number of ways including energy expenditure that can aid weight management. Besides the energy expended during exercise, there can be increased energy expenditure and fat oxidation after exercise. This phenomenon is called excess post-exercise expenditure (EPEE).

Studies have shown that EPEE is affected by the duration and intensity of aerobic training. However, a large EPEE is associated with either very long duration training or very high intensity training, or a combination of the two. Resistance training also has been associated with EPEE and there is some suggestion from research that higher EPEE is associated with higher intensity training. Traditionally intensity has been defined as a percentage of a one repetition maximum (1RM) and not the actual degree of effort. It is not clear what effect the volume of resistance training has on EPEE. Therefore, the purpose of this study was to compare EPEE after training with a 1-set or a 3-set protocol.

The study involved 15 young (average age = 24.2) women who were experienced resistance trainees. Prior to the exercise sessions, women received a state-of-the-art metabolic exam. Then in randomized assignment, the women performed one of two exercise protocols with the bench press, leg press, pulldown, leg curl, overhead press, knee extension, biceps curl, triceps pushdown, and abdominal crunch. One protocol involved performing 1 set (1 circuit) of each exercise using a resistance that represented the resistance they could use for eight repetitions (8 RM). The second protocol involved performing the same exercises but with three sets (3 circuits). Whichever protocol the women had not performed on the first day of testing was performed two days later.

All exercise training was supervised and 90 seconds rest was allowed between sets. Women were pushed to complete as many repetitions as possible for each set. Metabolic measures were taken throughout the exercise training sessions and then 30, 60, 90, and 120 minutes after exercise during recovery.