Nutrient muscle tissues and replenishment of glycogen

Business, Strategy

Nutrient timing is a popular strategy which supports theconsumption of a combination of nutrients- primarily carbohydrates andproteins- around the individual’s workout session.

It has been claimed that this approach can produce dramaticimprovements in body composition. It has even been postulated that the timingof nutritional consumption may be more important than the absolute daily intakeof nutrients. While some research has demonstrated that the timed ingestion of nutrients–majorly carbohydrates and proteins- may significantly affect the adaptiveresponse to exercise, some show that the timing of nutrients hardly play a roleif the target macronutrients are fulfilled by the end of the day.

Variousresearches have postulated that an anabolic “ window of opportunity” existsafter a training session whereby a limited time exists after training tooptimize training-related muscular adaptations. In this paper, we identifythe dietary guidelines for athletes and its physiological and psychologicalimplications on beginners, intermediate and advanced lifters and if nutrient(carbohydrates and proteins) timing, in fact helps an individual maximize hispotential. We will also discuss about a popular dieting strategy, Carb Backloading, in detail and review if there are any additional benefits to consuming carbsonly post-exercise. Introduction Over the past few years, there have been a number ofextensive research studies revolving around the concept of nutrient timing. This was based on the consumption of nutrients- majorly carbohydrates and proteins-in and around a training session. Thestrategy is designed to maximize exercise-induced muscular adaptations andfacilitate repair of damaged tissue 1. Theoretically, consuming the proper amount of nutrientsaround the training session not only helps in the restoration of damaged muscletissues and replenishment of glycogen reserves, it also aids in better bodycomposition and glycogen super-compensation, wherein after a bout of resistancetraining, the muscles are able to hold a greater amount of glycogen than theynormally would be able to, hence super-compensating the muscle glycogenreserves and making it look fuller and bigger.

Also, researchers have madereference to an anabolic " window of opportunity" whereby a limited time existsafter training to optimize training-related muscular adaptations 5. However, this depends on a number of factors – the duration between training bouts, howwell trained the athlete is – beginner, intermediate or advanced. Nutrient 1: Proteins Pre-exercise ingestion of proteinsMany studies have been conducted to explore the use of pre-exercise PRO and CHO ingestion inpreventing acute exercise-induced muscle damage. Tipton et al. 15 reported that theingestion of a mixture of essential amino acids and CHO before resistance exercisewas more effective for the stimulation of post-exercise muscle proteinsynthesis than ingesting the same mixture immediately after exercise.

This wasattributed to the combination of increased amino acid levels at a time whenblood flow is increased during exercise, thereby offering a greater stimulationof muscle protein synthesis by increasing amino acid delivery to the muscle. However, in a following study, the same study group was unable to demonstratethe same findings when examining the impact of 20 g of whey proteiningested before as opposed to 1 h after resistance-type exercise on muscleprotein balance measured over a 4- to 5-h recovery period 16. This study, along with a few others, have concluded that rate of muscle protein synthesisis stimulated by ingestion of protein sources and the timing of proteiningestion is not important. 14, 16, 17, 18. Intra-exercise ingestion of proteinsThe ingestion ofprotein before or during exercise could be of even more benefit during theearly stages of recovery from more intense exercise bouts and has beeninvestigated in many short term studies 19. In one study, participants completed 3 h of cycling @ 45 – 75% VO2max, followed by a time to exhaustiontrial at 85% VO2max. During each session, participants consumed either aplacebo, a 7. 75% CHO solution, or a 7.

75% CHO/1. 94% PRO solution. While the CHOonly group increased time to exhaustion (19. 7 ± 4. 6 min) versus the placebo(12.

7 ± 3. 1 min), the addition of PRO resulted in even greater performance(26. 9 ± 4. 5 min) 20. Another study by Saunders et al. analyzed the impact ofa CHO + PRO combination for its ability to improve performance and minimizemuscle damage 21.

Cyclists exercised toexhaustion on two different occasions separated by 12 – 15 h. During exercise, the participants were given a CHO solution or a CHO+PRO solution. It was foundthat the participants who ingested the CHO+PRO solution had a much higherincrease in performance and the muscle damage markers were significantly lower, suggesting the CHO + PRO supplement helped to attenuate the muscle damageassociated with prolonged and exhaustive exercise. Similarly, few other shortterm studies showed a positive effects of consuming a CHO+PRO solution duringexercise on attenuating muscle damage by lowering muscle damage markers such ascreatine kinase 22, 23.

However, in a long term study conducted for one weekon elite cyclists by Mette et al., the supplementation of a PRO+CHO solutionduring exercise did not improve recovery or performance in elite cyclistsdespite high demands of daily exhaustive sessions during the one-week trainingcamp. 24 Post-exercise ingestion of proteinsMost of thestudies that have been done on nutrient timing are based on protein consumptionafter a training session and whether or not an " anabolic window" exists whichcould help an individual maximize his/her training-related muscularadaptations. Some of the earlier studieswhich were done supported the idea of an anabolic window post training. Forexample, Esmarck et al. 25 provided evidence that consuming proteinimmediately post training enhanced muscular adaptations better than when theprotein intake was delayed. Thirteen untrained elderly male volunteers werematched in pairs based on body composition and daily protein intake and dividedinto two groups: P0 and P2. P0received a protein supplement immediatelypost-exercise while P2 received the same supplement 2 hours following theexercise bout.

After the end of the study period, they noticed that cross-sectionalarea (CSA) of the quadriceps femoris significantly increased in the P0 groupwhile no significant increase was seen in P2, hence suggesting that delayingpost-workout nutrient intake may impede muscular gains. In contrast to this, there have been numerous studies which have refuted the existence of the” window of opportunity” whereby a limited time exists after training tooptimize training-related muscular adaptations. Verdijk et al.

26 didn’tnotice any increase in skeletal muscle tissue in elderly men from consuming apost-exercise protein supplement. 26 elderly men were randomly assigned to aprogressive, 12 week resistance training program with (protein group) orwithout (placebo group) protein provided before and immediately after eachexercise session. After 12 weeks, no significant differences in muscle strengthor hypertrophy were noted between groups indicating that timed nutrientsupplementation does not enhance training related adaptations. Similarly, Hoffmanet al. 27 conducted a study on 33 well- trained young men with proteinsupplementation given either in the morning and evening or immediately beforeand immediately after resistance exercise. At the end of the study, nosignificant between-group or absolute changes in body composition was observed. A lot of other studies have echoed the same sentiment when it came to timing ofprotein supplementation, be it in untrained individuals or trained athletes28-31.

Summary1. Pre-exercise/ intra-exercise intake of proteindoesn’t have any additional benefits as compared to any other time of the day. However, addition of a PRO+CHO solution during prolonged endurance events might offsetmuscle damage. 2. The post-exercise’anabolic window’ lasts a lot longer than what was originally hypothesized, indicating that ingesting a protein supplement immediately post exercisedoesn’t have any additional benefits.

Nutrient 2: Carbohydrates Pre-exercise ingestion of carbohydratesGlycogen is considered to be quintessential for resistancetraining athletes, with 80% of ATP being derived from glycolysis. MacDougall et al. 7 demonstrated that asingle set of elbow flexion at 80% of 1 repetition maximum performed tomuscular failure caused a 12% reduction in mixed-muscle glycogen concentration, while three sets at this intensity resulted in a 24% decrease. Similarly, Robergs et al.

8 reported that six sets of 70% one repetition maximum(1 RM, I-70) and 35% 1 RM performed to muscular failure resulted in a 26. 1%reduction of glycogen stores in the vastus lateralis while six sets at thisintensity led to a 38% decrease, primarily resulting from glycogen depletion intype II fibers compared to type I fibers. As glycogen levels diminish, ATPproduction is hampered, exercise intensity decreases which results insuppression of the immune system 1. Research involving the ingestion of singlehigh CHO feedings has also demonstrated the promotion of higher levels ofmuscle glycogen and an improvement of blood glucose maintenance (euglycemia) 1.

This ensures the athlete is able topush harder during the training and the ATP production is enhanced viaglycolysis. Also, glycogen availability also has been shown to mediate muscleprotein breakdown. Lemon and Mullin 9 found that nitrogen losses more than doubled following about of exercise in a glycogen-depleted versus glycogen-loaded state. However, not all studies showed the same result. Hawley and Burke summarized severalstudies that administered some form of CHO within one hour prior to exercise: one study reported a decrease in performance, three studies reported anincrease in performance and some studies reported no effect 10. In light of these conditions, maintaining ahigher muscle glycogen level before training appears to be beneficial toresistance training results. Intra-exercise ingestion of carbohydratesMost of the research involving the consumption ofcarbohydrates during workout have been performed on endurance athletes whotrain for longer periods of time (at least 90 minutes) or resistance trainingbouts spanning for very long hours. This is most likely because this is whenglycogen stores will be significantly depleted because of the duration of theworkouts, as opposed to a regular resistance training session in which glycogencan be depleted by about approximately 36-39% only 1.

Carbohydrates during an endurance event maintainhigh rates of CHO oxidation which undergo glycolysis to provide ATP, offsets muscle damage and preventhypoglycemia 11. A study conducted by Kulik et al. studied the effects of supplemental carbohydrate (CHO) ingestion on theperformance of squats to exhaustion 12. In this study, the subjects were madeto do sets of 5 reps to exhaustion at 85% of their 1RM. Subjects consumed0. 3g. kgCHO.

bodymass or a placebo of equal volume immediately before exerciseand after every other completed set of squats. There was no significant statisticaldifference between groups in total sets, volume, work or the rate of perceivedexertion. This study suggests that intra workout carbohydrates might not be asbeneficial for an athlete performing resistance training. Post-exercise ingestion of carbohydratesIt is common lore that the post- exercise carbohydrates musthave a substantial glycemic and insulinemic response in order to optimizerecovery and there are studies which support this claim.

One such study showed that glycogen storage was2–3 times faster during four hours post-exercise resulting in greater glycogenstorage at four hours rather than later in the day, suggesting that delayingthe ingestion of a carbohydrates post-exercise will result in a reduced rate ofmuscle glycogen storage 4. However, there are numerous studies whichsuggest that consuming carbohydratesimmediately post-workout may not aid in faster glycogen replenishment.

In astudy conducted by Parkin et al., 6 trained cyclists cycled at 70% of VO2 maxfor 2 hours followed by four 30 second sprints. Post exercise, all subjectswere given 5 high glycemic index meals over a 24 hour period, the first threebeing fed immediately post workout and 3 being fed starting 2 hours after thetraining session. Muscle biopsies taken at 8 and 24 hours revealed that therewas no difference in muscle glycogen or glucose-6-phosphate in either trial13. These studiespresent conflicting opinions but taking all the relevant points intoconsideration, it becomes quite clear that accelerating glycogen resynthesis isimportant for endurance athletes when the duration between two events is lessor for resistance training athletes who perform 2 training sessions in a dayprovided the same muscles are being worked in both the sessions. Summary1.

Pre-exercise intake of carbohydrates mayhelp with increased glycogen levels which translates to higher energy output inthe training session. 2. Intra-exercise intake of carbohydrates aremore beneficial for endurance/resistance training athletes who train for verylong hours and are at risk of significant glycogen depletion. 3.

Post-exercise intake of carbohydrates helpwith glycogen resynthesis but the rate remains the same even at 24 hours, indicating that completing the CHO requirements before the next trainingsession is optimal enough for athletes. Carbohydrate Backloading: A reviewCarbohydrate Backloadingis a dieting strategy that was popularized by John Keifer. This strategy emphasizeson keeping carbs at an absolute minimum throughout the day and ingestingcarbohydrates after the training session. 34Mechanism of carbohydrate Backloading: It was hypothesized that carbohydrate backloadingtakes advantage of the non-insulin mediated uptake of glucose by the muscletissues post-exercise, because of GLUT4 translocation, as opposed to in themorning, when insulin sensitivity in both muscle and fat tissue is generallyhigher 32. Similar to GLUT (GlucoseTransporter) 1-3, GLUT4 and GLUT12 are a set of glucose transporters which arepresent in muscle and fat tissue.

While GLUT 1-3 are exposed to the cell surface, GLUT4 are tucked below the surface within the cellular membranes. Due to thiswithdrawn nature of GLUT4, this only reacts to the presence of insulin bymoving from the interior of the cell to its surface. Thereby, this insulin-mediated transport ofglucose transports high volumes of glucose in the cells containing these GLUTs(both muscle and fat tissue).

33, 34However, resistancetraining mimics the function of insulin in muscle cells and GLUT4 rises to thesurface shuttling glucose into the muscle tissue. This non-insulin mediateduptake of glucose by the muscle tissues post-exercise is postulated to haveincreases in the skeletal muscle tissue without any significant increases inadipose tissue. 34Research on carbohydrate backloading: The most popular researchto support the theory of CBL is a 6 month study.

In this study, Sofer et al. 35authors compared the effects of carbs eaten mostly at dinner (experimentalgroup) vs. eaten throughout the day (control group) in a group of 78Israeli police officers. It wasfound that reductions in weight, body fat and waist circumference were greaterin the evening-carb experimental group vs. the control group.

In addition, glucose control, inflammation, blood lipids and satiety were improved to agreater degree in the evening-carb group. However, thereare a few limitations to the design of the study. The subjects were fed a dailyaverage protein intake of 0. 66-0. 76 g/kg, which is much less than whatis consumed by resistance trainees aiming for a better body composition, whichquestions the applicability of the research to this population.

Also, theexperimental group lost an average 11. 8 percent of their body weight in 6months as compared to the control group who lost an average 10. 9 percent, whichisn’t statistically significant (<1%) over 6 months. Also, the experimentalgroup started at a greater weight to begin with. There are othercontrolled studies 36, 37 which were conducted, but no changes in bodycomposition or weight loss were observed, however they were conducted for veryshort durations (15 days and 18 days). Carbohydrate backloadingdoesn't provide any additional benefits in fat loss/ muscle gain when comparedto a normal diet when calories and protein are equated. Though, in lightof the limited evidence, it does seem that shifting caloric (and carbohydrate)intake to later in the day (around the training session) may provide a slightadditional benefit with respect to body composition, better trainingperformance and markers of health and disease.