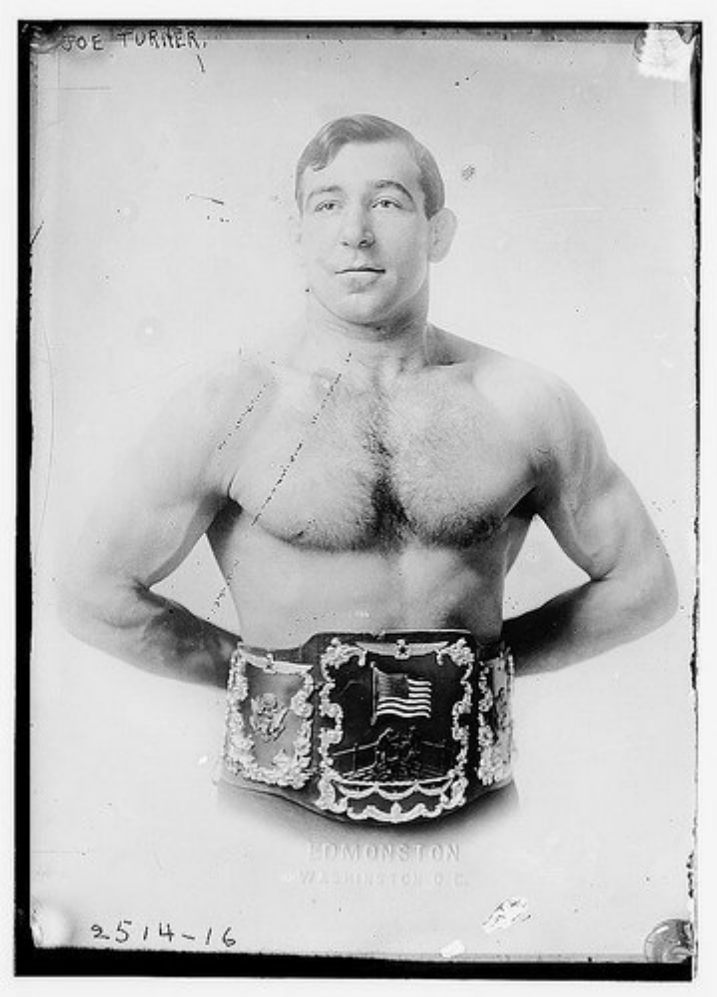
Post Workout Recovery Modalities

By: Sean Casey



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About the Author

Sean Casey is a graduate of the University of Wisconsin-Madison with degrees in both Nutritional Science-Dietetics and Kinesiology-Exercise Physiology. Sean graduated with highest academic honors as one of the top students in both the Nutritional Science and Kinesiology departments.

During college, Sean was active with the UW-Badgers Strength and Conditioning Department. He has also spent time at the International Performance Institute in Bradenton, FL where he worked with the USA U-18 National Men's Soccer team. More recently, he has worked with multiple NFL 1st round NFL draft picks and All-Pro NFL athletes at the Athletes Performance in Tempe, AZ. Sean is also active in the field of sports nutrition where he has consulted with a wide variety of organizations including both elite (NFL's Jacksonville Jaguars) and amateur athletic teams.

Currently, Sean Casey is the president of CasePerformance, an organization focused on providing its clients research based physical performance and sports nutrition advice. He can be reached though his website http://www.caseperformance.com/.

Post Workout Recovery Modalities Part Ia: Hydrotherapy

Quick Hit Summary

Water therapy is a common modality to enhance muscle recovery post workout. Sitting in chest high thermoneutral water for 20-30 minutes may accelerate waste removal while increasing blood flow to working muscles. Cold, hot and contrast water temps are also commonly used to assist recovery. The goal of cold water therapy is to reduce inflammation whereas hot water purportedly increases muscle blood flow. Contrast water therapy involves alternating between hot and cold water baths to induce a vaso-pumping effect. Current evidence does not support the theory behind these latter 2 therapies simply because the heat (from the water) is incapable of penetrating more than a couple centimeters into the skin. Thus, there is no stimulus to increase muscle blood flow.

Post Workout Recovery

For professional sport athletes, there is a fine line between allowing enough time for the human body to recover from an intense workout and getting in enough practice/floor work to prepare for an upcoming contest. Athletes and coaches are always looking to shorten the former in order to allow more of the latter. The same often holds true for recreational athletes. For example, endurance athletes often prepare for distance races/triathlons by training 2x/day. Additionally, many individuals lift weights 4x/week. Regardless of what end of the competitive spectrum you fall on, common sense tells us that a 2nd training session will not be productive if one hasn't recovered from the 1st workout. String together enough non productive training sessions and other than sore muscles, all you have is wasted time.

{One exception does apply to this line of thinking. During an "overreaching" training phase, individuals complete multiple training sessions while still in a fatigued state. In turn, performance will decrease for a short period of time until the gains are "realized" during the subsequent training block. I stress that this is a PLANNED period of decreased training performance vs. the UNPLANNED non-productive training sessions I'm referring to above.}

In past articles (found at www.caseperformance.com), I've stressed the role that nutrition has on athletic performance. As discussed, properly timed nutritional interventions provide the building blocks necessary for growth, enhancing the body's ability to recover from hard workouts. There are numerous other methods, collectively referred to as post workout recovery modalities (**PWRM**), that athletes also utilize with hopes of accelerating this process. These PWRM involve hydrotherapy, compression garments, massage, etc. In this 1st article of my PWRM series, I'd like to focus on the evidence supporting the use of hydrotherapy.

Physiological Factors Influencing Post Workout Recovery

Before I get too deep into the various PWRM, I'd like to briefly discuss one of the primary non-nutritive factors hypothesized to influence post workout recovery. During the 1970-1980's various studies found lactic acid impaired strength and contraction velocity in samples of isolated muscle tissue[1]. {Lactic acid breaks down and forms lactate and an H+ acid ion. Therefore for the remainder of this review, I'll use lactate, lactic acid and acid interchangeably}. **Based off these early findings, many researchers evaluated PWRM on their ability to remove lactate from muscle tissue post workout**. Similarly, coaches and athletes employ post workout techniques aimed at removing lactate from muscular tissue. For instance, our high school track coach used to have us lie on our backs and rest our legs on an elevated surface. The theory was that lactate would "drain" out of our muscle tissue, allowing our legs to be fresher for the following day's workout.

Interestingly, it turns out that **lactic acid may not be the best form of measurement with respect to evaluating the effectiveness of a PWRM**. As pointed out by Cairns SP, it may have a much smaller effect on muscle fatigue than was previously hypothesized[1]. Thanks to advances in technology, scientists are now able to study muscle tissue closer to physiological temperatures (old studies were completed at muscle tissue held at cooler temperatures, 50-68ºF). As shown by Westerblad et al., acid had little effect on contraction velocity when completed on muscle tissue held at 89ºF[2]. On the other hand, a 2006 study by Knuth et al. did indicate that lactic acid decreased muscle contractile power even at warmer temperatures[3].

Although the lactate question is still being debated amongst scientist, athletes must ask themselves if the research is even applicable to their post training recovery protocol. **Although lactate may induce muscular fatigue, it's quickly metabolized within the body** (1/2 life: muscle- 9.5 minutes; blood- 15 minutes), **and eliminated from our system 90 minutes after an exercise session has been completed**[45]. Thus, exercise induced lactic acid from one workout is likely not even present during a subsequent workout.

PWRM #1: Hydrotherapy (thermoneutral water immersion)

Figure 1 Jumping in a pool post workout does seem like a pretty tempting idea

One of the most popular PWRM is hydrotherapy (hydro means water). Fill a tub up with water, jump in and let the good times roll! The theory behind immersing oneself in water is that it increases hydrostatic pressure on one's body[6]. During exercise, a fluid shift occurs as oxygen and other nutrients are delivered from the circulatory system to the working muscle. Some of this blood/plasma immediately returns to the heart as would be expected. On the other hand, a portion of this fluid "pools" in the spaces surrounding muscle fibers. In the process, waste products, produced by the working muscles, are prevented from being efficiently reabsorbed.

Under resting conditions (ie- no PWRM employed), this fluid is slowly reabsorbed (via the lymphatic system) back into circulation. From here, waste products are broken down and removed from the body. The use of hydrostatic pressure accelerates this process[12]. **To see this positive fluid shift, it appears that one must immerse themselves in water up to the neck for at least 10-15 minutes**[8]. In one study, Johansen et al. observed a 16% increase in plasma volume in 8 men after they sat in chest high water for 30 minutes[7]. It does not appear that sitting longer than 30 minutes has any beneficial effect as studies carried out to 60 minutes still only report increases of ~16% in plasma volume[9].

Besides removing metabolic waste products, hydrotherapy also increases cardiac output[6]. {For reference, cardiac output is a measurement of the total amount of blood the heart pumps during a given time frame}. As a result, **the body's ability to deliver nutrients to muscle tissue (post exercise) may be enhanced**. When sitting in water at ~ sternum level height for 15 minutes, Gabrielsen et al observed a 32.6% increased in cardiac output in 9 healthy men[10]. Yun et al studied the effects of neck high water immersion in Korean women who were classified as young (mean age- 22.0 years), old (mean age- 54.5 years) and active water divers (mean age-

55.0 years). **All groups saw >48% increase in cardiac output after 20 minutes** of sitting in the water.

The above mentioned changes associated with water immersion are seen when sitting/standing in thermoneutral water (ie- thermoneutral water immersion- **TWI**). In TWI, the temperature of the water is similar to that of your body temperature. However, more often than not, coaches and trainers recommend their athletes jump in pools containing cold, hot or contrasting water temperatures. Why is this done and is it beneficial? Read on and find out!

Theory Behind Cold Water Immersion

Cold water immersion (**CWI**) is generally accepted to be water temperatures between 50-59ºF [6]. Advocates of cold water therapy promote this form of therapy for its **anti-inflammatory benefits** which include reduced blood flow (vasoconstriction). Although inflammation is needed to stimulate muscle growth, excessive inflammation may slow down the recovery process, possibly leading to overtraining syndrome[12]. CWI has also been found to **decrease perception of pain[13] while increasing subjective measures of recovery**[14]. On the other hand, drawbacks with CWI include a temporary decrease in heart rate[6] (which contributes to cardiac output), and muscle contraction power[15].

Theory Behind Hot Water Immersion

Hot water immersion (**HWI**) is generally accepted to be water temperatures between 100-115ºF. As one would expect, the use of HWI has effects completely opposite that of CWI. **Proponents claim that it increases the flow of nutrients** to muscle post workout via vasodilatation. Research indicates that the application of heat does increase blood flow through dermal (skin) tissue[1617]. However, with respect to muscle tissue, **there is a lack of evidence to support the notion that heat penetrates deep enough to affect muscle blood flow**. Myrer et al provide evidence that a 5 minutes of heat application (167º F) fails to penetrate > 1cm into muscle tissue[16]. Furthermore, Bonde-Petersen failed to find any significant increase in muscle blood flow following 20 minutes of HWI (110ºF)[17].

Theory Behind Contrast Water Therapy

Contrast water therapy (**CWT**) is a highbred recovery modality that involves alternating between both CWI and HWI. Protocols involve exposing oneself to one extreme temperature (similar to the ones mentioned above) for 30-300 seconds before introducing the opposite extreme temperature[6]. For example, one would jump in a cold water tub for 2 minutes, get out and sit in a hot whirl pool for another 2 minutes. This process could then be repeated 5-6x. **CWT is purported to induce a vaso-pumping effect** (ie- alternating between vasoconstriction during CWI and vasodilatation during HWI) **that accelerates the removal of waste products from muscular tissue**. There is a current **lack of evidence to support the notion that a vaso-pumping effect** actually occurs. As detailed in the preceding paragraph, external heat application fails to induce vasodilatation deep enough to affect blood flow in skeletal muscle.

Applying Theory to Practice

The aforementioned studies lay the ground work of how hydrotherapy may or may not benefit muscle recovery. However, these studies failed to examine its effects on subsequent exercise performance. **In part 1b of this ebook, we'll look at if post workout CWI, HWI and CWT affect subsequent physical performance.**

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18 Photo by David Hawgood. Accessed July 18, 2010 from http://www.geograph.org.uk/photo/251533

Workout Recovery Modalities Part Ib: Hydrotherapy

Quick Hit Summary

Hydrotherapy is a common method to enhance post workout recovery. Of the four types (cold, hot, contrast, thermoneutral), cold water, followed by thermoneutral or contrast appear to be the best options. However, long periods of cold water immersion will acutely inhibit muscle force capabilities. Thus, I do not recommend cold baths if you need to perform shortly (unless it's a quick dunk, ~2-3 min to cool off). Also I do not recommend the use of hot water immersion. Overall, there is great variation in the research on this subject. Thus, I encourage you to play around with cold water, contrast, and thermoneutral water immersions based off the guidelines presented in this article.

Hydrotherapy

Post workout recovery modalities (**PWRM**) are commonly employed by both elite and recreational athletes following intense workouts. One of the most common PWRM is hydrotherapy (hydro means water). In the first part of this ebook, we laid the ground work of how cold water immersion (**CWI**), hot water immersion (**HWI**), contrast water therapy (**CWT**), and thermoneutral water immersion (**TWI**) may or may not benefit muscle recovery. If you have not read that article, I highly recommend checking it out before continuing on with this article. Although the studies presented in Part 1a were crucial for our understanding of the physiological processes governing these PWRM, they failed to examine hydrotherapy's effectiveness on ensuing athletic endeavors. Therefore, in this installment, we'll look at how post workout CWI, HWI and CWT affect physical performance.

Figure 1. A quick dunk in the pool doesn't seem like too bad of an idea after an intense workout.

A Quick Caveat

Before I delve too deep in the literature regarding the efficacy of HWI, CWI, or CWT as PWRM, there is one caveat worth discussing. Most studies completed in athletic populations fail to include thermoneutral water. Rather, they tend to compare CWI or CWT to resting conditions. As mentioned in Part Ia, TWI exerts effects on its own via hydrostatic pressure. Furthermore, studies that do include TWI often fail to include passive resting conditions. For example, a study may only compare CWI to TWI. Thus, it can be somewhat challenging to discern if the results of a trial are necessarily due to the water temperature, hydrostatic pressure or a synergistic combination of both factors.

Hot Water Immersion

Current evidence indicates that hot water immersion (**HWI** water temp > 100-115ºF) is not the most effective method at accelerating post workout recovery. Vaile et al. found that passive recovery (ie- no PWRM) was just as effective as HWI on physical performance following a 5 days of intense cycling[1]. In a 2nd study completed by Vaile et al., researchers examined the effects of HWI on muscle recovery in 11 strength trained males[2]. Each individual participated in 2 intense leg press training sessions which were followed by either 14 minutes of HWI or passive recovery. HWI was **more effective at recovering isometric force recovery** at 24, 48 and 72 hours post workout. However, it was **no more effective than passive recovery at restoring**

dynamic power (measured via weighted squat jump), **pain perception and other markers** of physical recovery.

Cold Water Immersion

Aerobic Conditions

Cycling

Although results vary from study to study, it appears that 5-15 minutes of cold water immersion (**CWI)** benefits physical performance, especially if exercising in **hot** conditions (~90-104ºF; 40-43% humidity). Vaile et al. observed this in 10 experienced cyclists. In the study, each athlete completed 2 cycling performance trials[3]. After the first trial, participants took part in either 15 minutes of CWI (full body excluding neck and head) or active recovery (cycling at 40% peak power output). After 15 minutes of following their respective PWRM, individuals rested for another 40 minutes before repeating the performance trials. A week later this same protocol (2 performance trials separated by 60 minutes) was repeated except participants completed the opposite PWRM (ie- those who did CWI now did active recovery). Final results of the study indicated that **CWI was effective at maintaining performance whereas performance decreased by 1.8% following active recovery**. Although this may not seem like a huge drop in performance to the recreational athlete, this can be huge in sporting competitions.

Running

Bailey et al. studied the effects of CWI on physical recovery in 20 males following 90 minutes of intermittent shuttle **running**. Immediately following the exercise bout, participants took part in either 10 minutes of CWI (waist deep) or passive rest. Final results indicated that **CWI attenuated losses in muscle strength 24 and 48 hours post exercise** vs. the control group[4]. The same was true with respect to muscle soreness, with the passive rest condition experiencing more discomfort at each measurement point. A similar beneficial effect on subsequent performance was observed by Yeargin et al. in collegiate distance runners[5]. In this latter study, athletes followed the following process:

90 minute run completed at moderate intensity —>
12 minutes of CWI, ice water immersion (**IWI**) at 41ºF or quiet rest —>
15 minutes of walking, stretching, etc to “loosen” up —>
2 mile time trial

This process was completed on 3 separate occasions, allowing participants to complete the time trial under all recovery techniques[5]. Final results indicated that **CWI led to a 6% faster 2 mile time** vs. quiet rest. Unlike CWI, **IWI did not lead to significantly faster times** that control.

On the flip side of the coin, some studies completed in hot weather have found negative results after cold water immersion. Peiffer et al. had also found that a **longer CWI (20 minutes) decreased force capabilities** of the knee extensor muscles (see **Figure 2**) for up to 45 minutes post immersion[6].

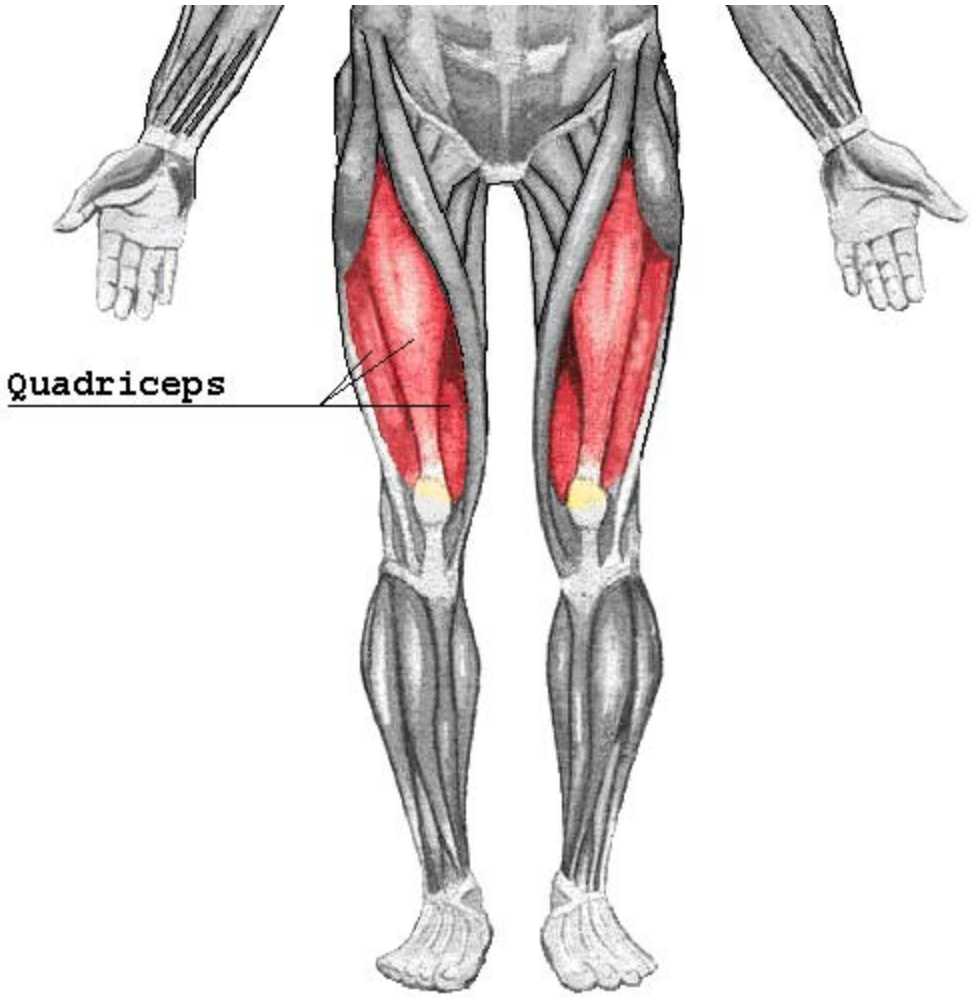

Figure 2. Individual muscles of the Quadriceps. The vastus lateralis is the most lateral of the quadriceps muscles highlighted in this picture. The rectus femoris is middle quadricep muscle and the vastus medialis is the innermost of the muscles. Picture obtained from commons.wikimedia.org/wiki/File:Quadriceps.png.

Anaerobic Conditions

Bike Sprints

Various studies which have examined the effects of CWI on muscle function after anaerobic training. Crowe et al. had 17 active individuals (13 male, 4 female) complete two 30 second bicycle sprint test separated by 1 hour[7]. All individuals completed 10 minutes of active recovery (completed on bike) followed by either quiet rest or a combination of CWI (10 minutes) and quiet rest. Final results indicated that **CWI actually decreased peak power (7.5%) and total work completed (4.3%)** during the 30 second performance trial.

Resistance Training

With respect to resistance training, Paddon-Jones and Quigley had 8 resistance trained males complete 64 eccentrically loaded elbow flexions. Following completion, one arm completed a CWI recovery (5 CWI sessions, each 20 minutes in length and separated by 1 hr) or passive recovery. Regardless of the PWRM employed by each arm, **similar decreases in performance** and similar ratings of muscle soreness were observed[8].

Plyometric Training

There have been 2 studies which have examined the effects of CWI following plyometric (jump/shock) training. Howatson et al found that 12 minutes of **quiet rest was just as effective as CWI** with respect to attenuating muscle soreness and restoring strength in 16 males[9]. Similar results were also observed by Jakeman et al. in 19 physically active females[10].

Training Adaptations

One research paper has examined the influences of CWI on training adaptations in previously untrained individuals. Results obtained by Yamane et al. indicated that CWI, used in conjunction with a 4 week forearm flexor (hand grip muscles) training routine, may attenuate gains made in forearm muscle endurance[11]. For reference, both forearms were trained; one received CWI while the other served as the control (passive rest). The same research team also examined how CWI would affect training adaptations in legs after a 4-6 week cycling program[11]. Similar to their first study, CWI (2, 20 minute immersions separated by 30 minutes) was completed on only 1 of the participant's legs. Once again, Yamane et al. noted **a blunted training effect in the limb that received CWI.**

I'm unaware of any paper that has examined the chronic effects of CWI on physical performance in trained individuals.

Summing Up Cold Therapy

As you can see, results vary considerably with respect to CWI and its acute (0-3 days) effects on exercise performance. The discrepancies between results may be best summed up by Vaile et al.[3] who said,

> "Little or no performance benefit is gained when CWI is used as a recovery intervention between bouts of local muscle exercise. After bouts of eccentric leg extension exercise and eccentric elbow flexion, CWI of the exercising limbs offered no benefit in the recovery of muscle performance or the level of muscular pain compared with control. Moreover, CWI of the lower limbs was shown to have a negative effect on repeated 30-s sprint performance compared with passive recovery. Collectively, these findings suggest that the performance benefit of CWI relies on a full-body cooling protocol, and the benefit is generally limited to high-intensity large-muscle-mass exercise, such as cycling or running, that is maintained for a duration of 15 min or longer."[3]

Contrast Water Therapy

Contrast water therapy (**CWT**) involves alternating 3-10 times between hot and cold water immersions. Each immersion lasts ~30-300 seconds before exposure to the opposite extreme temperature[12]. CWT studies have mostly been completed under anaerobic conditions.

Resistance Training

Vaile et al. examined the effects of CWT on subsequent physical performance in 13 recreational athletes (9 female, 4 males) following an intense resistance training session[13]. Individuals completed 5 sets of 10 reps on the leg press; all reps were eccentric at 140% of concentric 1RM (rep max). Immediately following each workout, athletes passively rested for 15 minutes or completed lower body CWT (1 minute CWI, 2 minutes HWI; repeat for 15 minutes). When comparing results between both PWRM, Vaile et al. found that CWT significantly **attenuated loss of isometric strength** 24 and 48 hours post recovery. CWT also **reduced thigh volume** (measure of swelling) 48 hours post recovery vs. resting conditions.

Running

Coffey et al. failed to see any beneficial effect of CWT following exhaustive treadmill running[19]. In their study, 11 trained males completed an exhaustive treadmill running protocol, followed by 15 minutes of CWI (5 cycles of 60 seconds cold, 120 seconds hot), quiet rest, or active rest (40% peak running speed). After 4 hours of recovery, the treadmill tests were repeated. Regardless of the recovery technique used, Coffey et al. **failed to find any significant difference** in the time taken to cover 400, 1000, or 5000 meters.

Comparative Studies

Cold vs. Thermoneutral Water Immersions

Various studies have compared the effects of various hydrotherapy techniques within the same study. Sellwood et al. examined the effects of CWI vs. TWI on muscle recovery following a bout of eccentric leg extensions in 40 untrained participants (11 males; 29 females)[14]. Both post exercise immersion protocols involved standing in water set to a height equal to the anterior superior iliac spine (think top of hip) for 1 minute, stepping out of the pool for 1 minute, and then repeating the process 2 more times. Final results indicated that **CWI was no more effective than TWI on most pain or performance measurements** (isometric strength, single leg hops). A similar lack of differences between TWI and CWI (1 minute in, 1 minute out; repeat 5x) on performance measurements were found by Rowsell et al. in high-performance junior male soccer players over the course of a 4-day simulated soccer tournament[15].

Cold Water Immersion vs. Contrast Water Therapy vs. Passive Rest

The effects of CWI, CWT and passive rest following both a **simulated game** (four 20 minute circuits using athletic movements), as well as an exhaustive shuttle run, were measured by Ingram et al. in 11 team sport athletes (all males)[16]. Immediately and then again 24 hours post exercise, athletes completed 1 of the following PWRM for 15 minutes:

(Water level for both water protocols was at belly button)

- Passive rest
- CWI
- CWT (3 cycles of 2 minutes cold, 2 minutes hot)

Prior to exercising, and again 48 hours post workout, athletes completed a repeated sprint test (running). Additionally, Ingram et al. recorded isometric strength of the lower limb muscles[16]. **Superior results were seen when using CWI.** Following the passive and CWT recovery techniques, individuals saw significant decreases in performance (~1.0%). In contrast athletes did not experience any significant decline between pre and post sprint performance when using CWI as the PWRM. Furthermore, muscle soreness ratings were also significantly lower for the CWI vs. passive or CWT conditions 24 hours post exercise.

Cold Water Immersion vs. Contrast Water Therapy vs. Hot Water Immersion vs. Passive Rest

Vaile et al. carried out an interesting study in which they looked at the effects of CWI, HWI, CWT and passive rest in 38 strength trained males following a **resistance training** session (leg presses, similar protocol as described earlier[13])[2]. At 0, 24, 48 and 72 hours post exercise, athletes completed the following recovery methods:

- Passive rest – 14 minutes (all participated)

Hydrotherapy – 14 minutes (individuals completed 1 of the following 3; water level set just below neck).

- HWI
- CWI
- CWT (7 cycles of 1 minute cold, 1 minute hot)

Compared to passive rest, all 3 hydrotherapy techniques were effective at reducing isometric squat strength losses. However, **CWI and CWT were more effective at reducing edema** formation than HWI. Additionally, **CWI and CWT were found to restore dynamic squat jump performance (measurement of power) faster** than passive recovery. In contrast, HWI was no more effective than passive recovery with respect to restoring dynamic squat jump performance.

Applying Hydrotherapy to Your Program

As you can see, the research is across the map with regards to the effectiveness of post workout hydrotherapies. There are a few generalities that can be formed though:

- The guidelines made by Vaile et al.[3] regarding CWI are applicable to CWT as well (in my opinion).
- HWI is the least effective of the hydrotherapy techniques.
- TWI may be just as effective as CWI.
- CWI should be completed close to the conclusion of exercise for best effects. Delays seem to reduce effect. Also, don't expect to have strong muscle strength immediately after getting out (although pain is reduced). It may take 45+ minutes post immersion before this strength is restored.
- Whichever technique you use, immerse your full body (excluding head/neck) for 10-15 minutes to see a positive fluid shifts. (Please read Part Ia).

Personally I like to go 3-5 minutes of CWI followed by another 5-15 minutes immersed in cool water (Think temperature of swimming pool water on hot day… not cold, but cool enough to make you feel comfortable despite outside temp). I don't ever go more than 5-8 minutes of CWI just because I'm paranoid about excessively blunting the inflammatory response. Acute inflammation appears to kick off the anabolic response in muscle tissue[17]. Thus, I primarily use CWI because I get an analgesic effect during this time period and it helps to me to feel more rejuvenated for my next workout. Then I follow it up with TWI because it helps "accelerate" the inflammatory effect vs. the blunting effect seen with CWI.

I know what you're probably thinking right now… what the heck does accelerating the inflammatory response mean? When the body gets cold (ie- CWI or applying ice packs to skin) the metabolic processes governing the inflammatory process shuts down[18]. In contrast, water closer in temp to TWI accelerates inflammation by pushing excess fluid away from your muscles and back through the circulatory system (see part 1a of article)[12]. Additionally, hydrostatic pressure increases cardiac output, possibly enhancing flow of nutrients to muscle tissue.

Bottom Line

In conclusion, the rules governing hydrotherapy are not exactly set in stone. What works well for me may not be the best method for you. Thus, based off the guidelines I mentioned during this

article, I encourage everyone to play around with various methods and see what works best for you.

Good Luck!

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Post Workout Recovery Modalities Part II: Compression Gear

Quick Hit Summary

The use of compression gear has long been used by sports medicine professionals as a means to limit inflammation post injury. Within the past few years, the use of compression gear, as a post workout modality, has increased in popularity. For the most part, the use of compression gear does not seem to enhance muscle recovery. One may experience a decreased perception of muscle pain while wearing CG. However attenuation of post workout muscle soreness does not appear to enhance subsequent athletic performance. On the other hand muscle soreness is a common symptom of overtraining syndrome. Thus, wearing compression gear may reduce the risk of becoming "stale." However, more research must be completed in this area.

Compression Gear

In the first part of this ebook, I focused on the potential benefits of Hydrotherapy (Hydrotherapy Part Ia, Hydrotherapy Part Ib). The next post workout recovery modality (**PWRM**) that I'd like to discuss is compression gear. As its name implies, compression gear (**CG**) consists of tight fitting undergarments.

Compression therapy has long been used in sports as a treatment modality for soft tissue injuries (sprained ankles, etc). In fact, it's part of the famous RICE protocol (rest, ice, *compression*, elevation) prescribed by athletic trainers following an acute injury. Similar to hydrotherapy, CG creates an external pressure on one's body, reducing edema and possibly assisting the removal of metabolic waste products. Although individuals in the sports medicine field have used this modality for years, the use of CG as a PWRM is a relatively new idea for many athletes. However, this is beginning to change as sports apparel corporations (Adidas®, Under Armour®, Skins™) have began marketing their respective CG. However, before we rush to the local sporting goods store and purchase an outfit, let's look at the evidence surrounding this PWRM.

Figure 1 An individual wearing compression gear

To my knowledge, Kraemer et al. was the first research group to study the use of CG in healthy individuals (ie- no clinical orthopedic injuries such as sprains, etc)[2]. In the study, they induced muscle damage in 20 untrained females by having them complete 2 sets of 50 **arm curls**. Upon completion, 10 individuals wore a compressive sleeve over their bicep and elbow joint for 5 consecutive days. By day 3 those wearing the CG had significantly less pain, greater range of motion and enhanced recovery of muscle force vs. those in the control group.

The effect of CG on muscle recovery following a **full body resistance training** protocol has also been examined. Kraemer et al. examined the effects of a full body CG on recovery in 20 highly trained athletes (11 male, 9 female) following 2 heavy resistance training sessions[3]. The resistance protocol involved both upper and lower body lifts (Squat, RDL, Bench Press, Bent Over Row, etc). Following each training session, individuals wore regular clothing or full body CG (Recharge™) for 24 hours. At the conclusion of this recovery period, various physiological and psychological outcomes were assessed. Results of the study can be seen in **Table 1 (page 23).** For reference, CG was removed prior to testing.

Table 1 Effects of wearing CG vs. normal clothes following an intense resistance training session. For each outcome, an "increase", "decrease: or "same" will be noted for both sexes. These designations are for wearing CG with respect to normal clothing For example, a decrease in the muscle soreness category designates that CG decreased muscle soreness vs. normal clothes.

Outcome	Men	Women
Muscle Soreness	decrease	decreased
Muscle Swelling	decrease	decrease
Resting Fatigue	decrease	decrease
Vitality	increase	increase
Bench Press Throw Power	increase	increase
Countermovement Vertical Jump Performance	same	same
Squat Jump	same	same
Quality of Sleep	same	same

On one hand, the bench press throw was the only physical performance measurement that improved with CG vs. normal clothes. On the other hand, wearing full body CG did improve most psycho-physiological outcomes when measured 24 hours post workout. Kraemer et al. also noted that wearing full body CG did not affect sleep quality.

Recovery Following Plyometric/Intermittent Sprint Training

Davies et al. had 11 trained athletes (7 female, 4 male) complete 2 plyometric training sessions (Depth Jumps - See **Figure 2** for protocol), separated from each other by 1 week[4]. Following each session, athletes wore complete lower body CG or regular clothing for 48 hours. After 2 days of wearing each clothing type, Davies et al. measured sprint speed (5, 10, 20m), 5-0-5 agility testing, countermovement jump height and perceived muscle soreness. When comparing post workout scores to those obtained prior to 1st session (ie- baseline scores), **regular clothing proved just as effective as CG**. In other words, CG did not enhance the body's ability to recover from the plyometric workout. **One partial exception to this rule was observed for muscle soreness**. Significant increases were noted 48 hours post workout while wearing regular clothing. This effect was not observed following the CG trial. For reference, all baseline measurements were obtained 1 week prior to the first plyometric session.

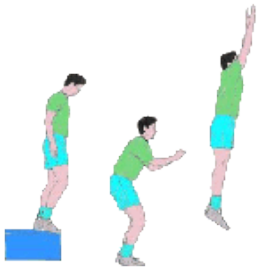

Figure 2 Depth Jumps were completed off a ~ 24 inch box. 5 sets of 20 reps were completed. Depth Jumps consist of stepping off a box and immediately going into a vertical jump upon hitting the ground[4].

Duffield et al. examined if CG would improve physical recovery following **simulated team game** (STG) activities in 14 **rugby** athletes[1]. The STG involved 4, 15 minute high intensity circuits which replicated movements seen during simulated team games. Sprints (5×20m sprints) and power tests (See **Figure 3**) were completed between quarters to assess the impact that CG had on physical performance. In its entirety, the training session lasted 80 minutes. Complete lower body CG was worn both during the activity as well as 15 hours afterwards. A day later, the STG was repeated to assess recovery measures. This same 2 day procedure was repeated 2 weeks later to allow all individuals to perform with and without the CG.

Figure 3 Power tests were completed on single man scrum machines which replicate the starting position in rugby matches.

Despite the apparent intensity of the training sessions, Duffield et al. failed to find decreases in power or sprint performance at any point during the 2 day testing period (ie- baseline vs. post 2nd quarter on 1st day vs. post game on 2nd day)[1]. This held true regardless of if the athletes were wearing CG or not. Although physical performance test results were equivocal, **a decreased perception of muscle soreness was noted** after wearing CG.

Comparative Studies

To my knowledge, only 2 studies have compared the effectiveness of CG to other PWRM. Gill et al. measured the effects of creatine kinase levels, a marker of muscle damage, in 23 elite **rugby** athletes[6]. Each athlete completed the following **post game** recovery protocols:

- Passive recovery
- Active recovery (7 minutes of stationary bike riding at 80-100 rpm)
- Contrast water therapy (3 cycles of 1 minute cold, 2 minutes hot; body immersed to top of pelvis)
- Complete lower body CG (12 hours)

Final results indicated that CG was more effective than passive recovery at restoring creatine kinase to baseline levels[6]. However, **CG was no more effective than active recovery or contrast water therapy (CWT)**. For reference, measurements were obtained 36 and 84 hours post game. There is one potential limitation with the study that may have influenced results. Following the passive recovery, athletes took part in a “post match function” whereas they completed their “normal post game routine” following the other 3 recovery sessions. Gill et al. failed to specify if these are the same procedures or not. Although you could say I’m being nit-

picky on that distinction, authors are generally very consistent with their language in scientific journal articles.

In a 2nd comparative study, French et al studied the efficacy of CG and CWT as post workout recovery modalities (**PWRM**) in 26 trained male athletes following a **Smith machine squatting session** (6 sets of 10 reps. Each set also included an eccentric based 11th rep)[7]. Following each session, individuals completed 1 of the following 3 recovery protocols:

- Passive recovery
- Contrast water therapy (4 cold immersions (1 minute), 3 hot immersions (3 minutes); completed while sitting upright in tub)
- Complete lower body CG (12 hours)

Prior to the training session baseline values were obtained for countermovement jump power, agility (M-test), 10 meter sprint, and 30 meter sprint[7]. These tests were repeated 48 hours following the exercise session. Counter movement jump power was the only performance measure that decreased 48 hours post exercise; **all groups were equally affected**. In order to assess muscle damage, pre and post exercise creatine kinase levels were also assessed. 24 hours post workout, **all groups experienced similar rises in creatine kinase**. This conflicts with results obtained by Kraemer et al. who found that CG significantly attenuated rises in creatine kinase when compared to passive rest[3]. However, those in Kraemer et al.'s study wore full body compression gear for 24 hours.

Other Notes

One clear benefit of CG is decreased perception of muscle soreness. This was noted in almost all of the studies reviewed for this article. This may have important long term affects in high trained athletes. Increased perception of muscle soreness is a common sign of overtraining syndrome[8]. Thus, decreasing post workout muscle soreness, via CG, may be a viable method to prevent athletes from becoming "stale".

I must point out that more studies are required before one can fully assess the efficacy of CG as a PWRM. As I've mentioned in previous articles, it takes a collection of studies, not a single study, to prove/disprove the effectiveness of a given treatment.

Bottom Line

Outside of two studies completed by Kraemer et al.[23], the use of compression gear (**CG**) as a post workout recovery modality (**PWRM**) is not supported by the current scientific literature. A few key differences present in Kraemer et al.'s studies may possibly explain these contradictory results. For example, in their study involving upper and lower body resistance training, athletes wore full body CG for 24 hours[3]. In contrast, other experimental protocols noted in the literature

often wore complete lower body CG for a 12-15 hours. Thus, CG may need to be worn for 24 hours and cover the entire body to exert positive effects. Before we blindly accept that full body CG improves physical performance, it's important to remember that Kraemer et al.'s research revealed that full body CG only enhanced upper body power. Lower body power, assessed via squat jumps and countermovement jumps, did not differ between recovery protocols[3].

In conclusion, the current scientific literature to support the use of CG as a PWRM is weak. One may experience a decreased perception of muscle pain while wearing CG. Unfortunately attenuation of post workout muscle soreness does not appear to enhance subsequent athletic performance.

I have no financial or other interest in any of the companies mentioned in this article

Adidas is a registered trademark for the Adidas Corporation

Under Armour's Recharge™ compression suit is a trademark or registered trademark of Under Armour® organization.

Skins™ is a trademark of SKINS USA, LLC

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