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17 minutes, 37
seconds

EDUCATION

How Research Can Help You Manage Detraining and Retraining

TAGS: Marilia Coutinho, sport performance, detraining, retraining, muscle memory, injury



Introduction

Yesterday I did many sets of few reps of empty bar snatches. After that, some drop snatches and presses. I got tired, my breathing was labored but I was happy: I've been ill during the past four months and it felt good to move. I barely managed to maintain a low volume and intensity in strength training for two months, insisted on a little treadmill walking to avoid insanity for another month and then nothing. I was basically slithering around the house under heavy medication, mildly stoned and weak. My strength and my conditioning decreased dramatically.

What happened to my bone metabolism? The quality and functioning of my skeletal muscles? My inflammatory indicators? My body composition (lean and fat mass)? They were all negatively affected. This is what we call "detraining".

If one is an athlete, after a period of detraining there is usually a period of retraining. "Retraining" is the set of adaptive responses to resuming training after a period of training cessation. The more experienced the athlete, the faster the retraining period up to performance levels before detraining.

There is not a lot of research about detraining and retraining. A Pubmed search with the title search term "detraining" resulted in 390 items (all time). The same search with the term "retraining" resulted in 915 items (all time). Most "retraining" titled articles are not related to sports.

My goals with this article are:

1. To assess the state of the art on the present scientific knowledge about training and retraining;
2. Whenever possible, to point out what health care professionals, coaches, and athletes might expect in detraining and retraining.

It might not be much but there's a reason for this choice: detraining and retraining are both scary. Detraining is often a process that follows injury or illness, both negative experiences with frequently unknown consequences over an athlete's performance. Retraining is something athletes usually engage in eagerly and with great expectation. Also, with great anxiety.

A little bit of knowledge can go a long way in managing this kind of stress.

What is Detraining

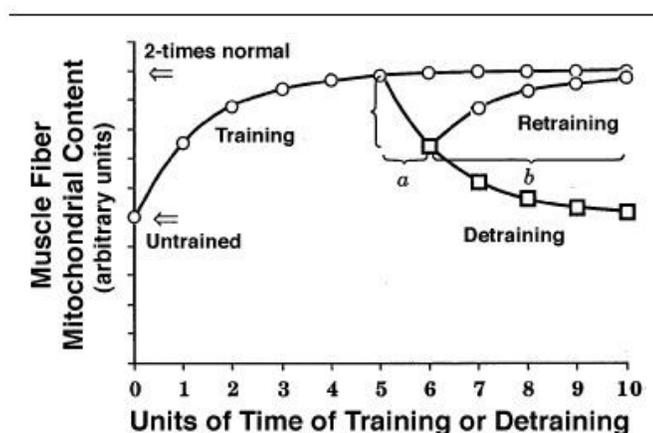
Detraining is the set of physiological responses to the cessation of training. Considering that the adaptive responses to training are usually physiologically positive, detraining responses tend to be negative to health and wellbeing. The physiological consequences of detraining range from very serious to negligible, depending on many factors.

Detraining is not just to "stop training for a while". Detraining is the set of physiological responses to the cessation of training. It frequently results in loss of performance. The exception is when detraining happens after a period of overtraining and burnout and performance gains are observed in the absence of retraining.

Detraining can be a serious process. It can be even more serious for high performance and elite athletes, even at a young age and for short periods. Sung et al (2017) demonstrated that a two-month detraining period resulted in adverse effects on early atherogenic dyslipidemia development, progressing insulin resistance, low-grade inflammation, and visceral adiposity in young elite taekwondo athletes.

Another study on elite male soccer players examined their bone metabolism (Koundourakis et al 2018). A six-week supervised detraining was sufficient to cause suppression of bone-formation rate and a parallel induction of bone resorption.

Several studies suggest oxidative capacity decrease after detraining (Liao et al 2016). The decrease in energy metabolism enzymes and ATP production led to the hypothesis of decreased mitochondrial content in the muscle fiber (Chi et al 1983, Staron et al 1981, Wibom et al 1992).



Kirshner's interpretation of Wibom et al (1992)

The claimed mitochondrial content effect was never measured and one case study about a detrained powerlifter suggested exactly the opposite (Staron et al 1981): the authors' hypothesis was that the mitochondrial content of the detrained fiber remains constant (for a strength-trained muscle), but as the volume of the fiber decreases, the mitochondrial volume percent increases.

The cause, type of sport, age and period of detraining are important factors concerning observed physiological results. More than one study shows that a four-week detraining period may have negligible effect on performance (McMahon et al 2019, Kraemer et al 2002). All other things being equal, there is a dose-response to time in strength loss (Bosquet et al 2013). This hypothesis was also confirmed by Vassilis and collaborators (2019) with young soccer players submitted to a four-week period of detraining, with no measurable effect on isokinetic strength on their lower limbs.

What is Retraining

Retraining is the process of reacquiring lost physiological function and performance after a period of detraining. It is faster and more efficient in more trained individuals.

Trained individuals, limbs and even muscles respond better and faster than "naïve" ones (previously untrained). This had been observed by athletes and coaches since time immemorial. A few decades ago, it was termed "muscle memory". Experimental results from animal models show an increased response from pre-trained versus naïve individuals even for short training periods and long detraining ones (Lee et al 2016).

Between 2010-13, the scientific community embraced the cellular explanation for the "muscle memory" phenomenon (Gundersen 2016):

Memory is a process in which information is encoded, stored, and retrieved. For vertebrates, the modern view has been that it occurs only in the brain. This review describes a cellular memory in skeletal muscle in which hypertrophy is 'remembered' such that a fibre that has previously been large, but subsequently lost its mass, can regain mass faster than naïve fibres. A new cell biological model based on the literature, with the most reliable methods for identifying myonuclei, can explain this phenomenon. According to this model, previously untrained fibres recruit myonuclei from activated satellite cells before hypertrophic growth. Even if subsequently subjected to grave atrophy, the higher number of myonuclei is retained, and the myonuclei seem to be protected against the elevated apoptotic activity observed in atrophying muscle tissue. Fibres that have acquired a higher number of myonuclei grow faster when subjected to overload exercise, thus the nuclei represent a functionally important 'memory' of previous strength. This memory might be very long lasting in humans, as myonuclei are stable for at least 15 years and might even be permanent. However, myonuclei are harder to recruit in the elderly, and if the long-lasting muscle memory also exists in humans, one should consider early strength training as a public health advice. In addition, myonuclei are recruited during steroid use and encode a muscle memory, at least in rodents. Thus, extending the exclusion time for doping offenders should be considered.

The mystery seemed to have been solved but we probably celebrated too early. Evidence suggests that the elevated myonuclear density acquired during training is lost during detraining (Dungan et al 2019).

Psilander and collaborators (2019), studying humans, observed a 20% strength increase in the trained group versus a 5% increase in the untrained group in the first training period, comparable to the muscle thickness (proxy to hypertrophy) response, although after the detraining and retraining, no differences in myonuclei density were observed.

We still agree that “muscle memory” exists but it doesn’t seem to be mediated by myonuclei density as previously thought (Murach et al 2019). New studies on epigenetic phenomena associated with skeletal muscle hypertrophy/atrophy are promising and offer plausible alternative models (Seaborne et al 2018).

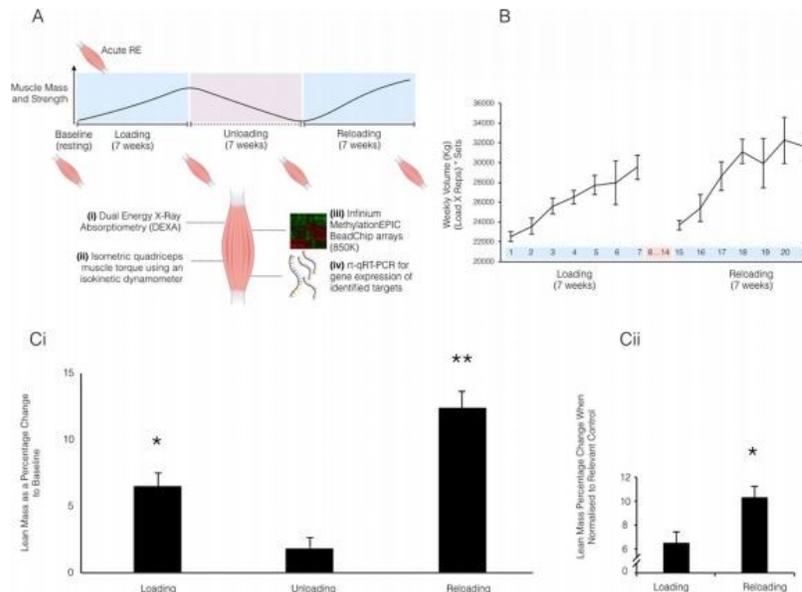


Figure 1. (A) Schematic representation of experimental conditions and types of analysis undertaken across the time-course. The image of a muscle represents the time point for analysis of muscle mass via (i) DEXA and strength via (ii) isometric quadriceps muscle torque using an isokinetic dynamometer. The images of muscle tissue also represent the time point of skeletal muscle biopsy of the Vastus Lateralis, muscle sample preparation for downstream analysis of (iii) Infinium MethylationEPIC BeadChip arrays (850 K CpG sites) methylome wide analysis. (B) Weekly total volume of resistance exercise undertaken by human participants ($n = 7$) during the first 7-week resistance exercise period (loading, weeks 1–7), followed by a 7 week cessation of resistance exercise (unloading, weeks 8–14) and the later second period of 7 weeks resistance exercise (reloading, weeks 15–21). Data represents volume load as calculated by ((load (Kg) x reps) x sets)) averaged across 3 resistance exercise sessions per week. Data presented mean \pm SEM. (Ci) Lean lower limb mass changes in human subjects ($n = 7$) after a period of 7 weeks resistance exercise (loading), exercise cessation (unloading) and a subsequent second period of 7 weeks resistance exercise (reloading). Total limb lean mass normalised to baseline (percentage change). Significant change compared to baseline represented by * and significant difference to all other conditions represented by **. (Cii) Total lean mass percentage change when loading is normalised to baseline, and reloading normalised to unloading to account for starting lean mass in both conditions. Pairwise t-test of significance indicated by *. All data presented as mean \pm SEM ($n = 7$).

Again, there is no definite consensus except that there is a “muscle memory” phenomenon. The elucidation of the actual mechanism needs more research.

Disease, Injury, and Planned Detraining

As is probably clear by now, the reason why detraining happened in any specific case is an important factor in how serious the health consequences acquired during detraining are and how retraining takes place. The main reasons for training cessation among athletes are injury and illness (Timpka 2014). There are two measures that matter in sports injury and illness epidemiology: incidence and burden, expressed as the number of lost days, hours or competitions.

Disease, Injury, and Their Burden

The main causes of detraining and determinants of retraining time and strategy are injuries and illness. What matters, in terms of individual and collective cost, is the burden in terms of lost days and missed competitions.

Bahr and collaborators (2018) have argued that we must shift our focus from injury and illness incidence to burden because both individually and institutionally, that is what matters. If a low burden injury has a high incidence, it affects the athlete, the team and the sponsors much less than high burden injuries with a lower incidence, but enough to damage the patient's athletic life, the team prospects, and the sponsors' investments.

The picture below illustrates this point: while lower leg contusion has a high incidence on football, it has a low burden. ACL tears, on the other hand, have a high burden.

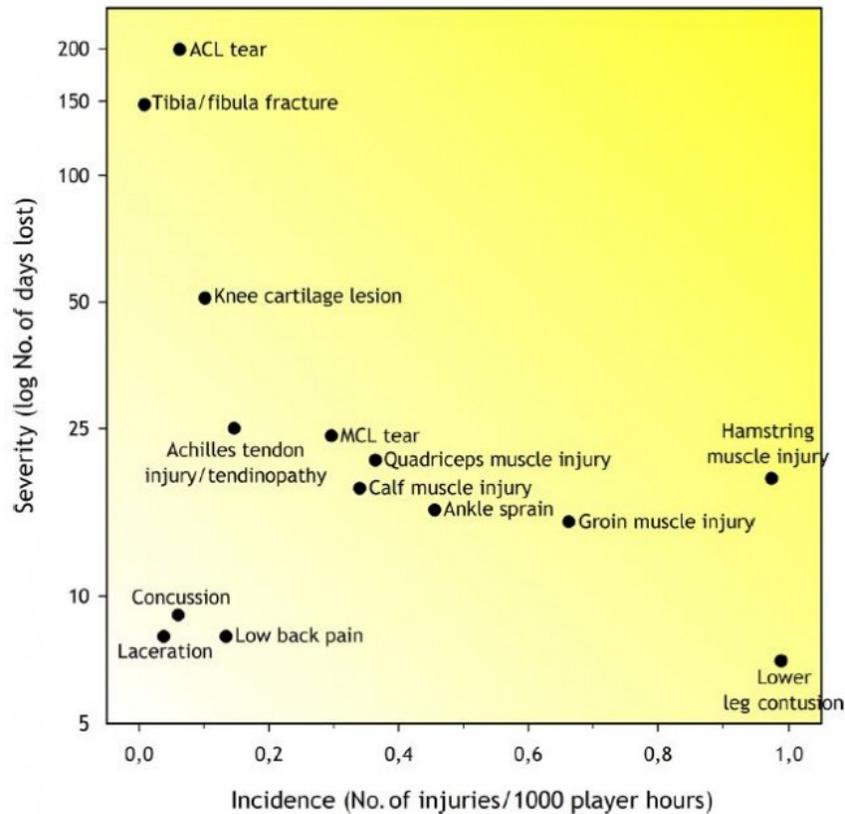


Figure 1 Quantitative risk matrix in UEFA Champions League football (based on data from the UEFA Elite Club Injury Study), illustrating the relationship between the severity (consequence) and incidence (likelihood) of the 14 most commonly reported injury types. For each injury type, severity is shown as the average number of days lost from training and competition (log scale), while incidence is shown as the number of injuries per 1000 hours of total exposure (match and training combined) for each injury type.

From Bahr et al (2018)

Different sports have different incidence and burden rates for injury and disease. It is important to observe that incidence and burden are very different for each type of injury. Acute injuries can have a lower incidence and higher burden or vice-versa.

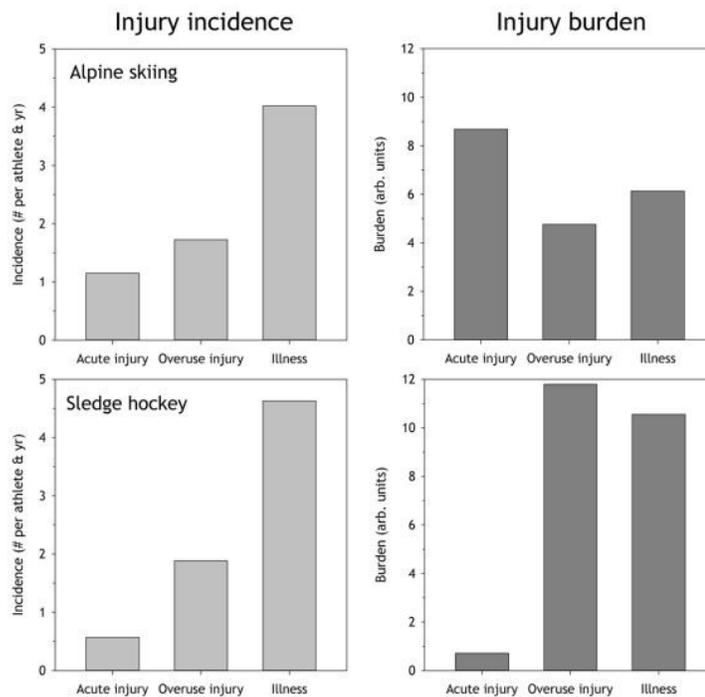


Figure 3 Injury incidence (number of injuries per athlete per year) and injury burden (arbitrary units) for the Norwegian Olympic alpine skiing team (top panels) and Paralympic sledge hockey team (bottom panel) during the 56-week period prior to the Sochi games.

From Bahr et al (2018)

Burden and incidence can be different for the training period and competition. Most coaches and athletes are painfully aware of the reality shown in the picture below: while injury incidence is lower in the final phase, when it happens, it tends to be worse and cause a higher number of lost days, and, frequently, lost competitions.

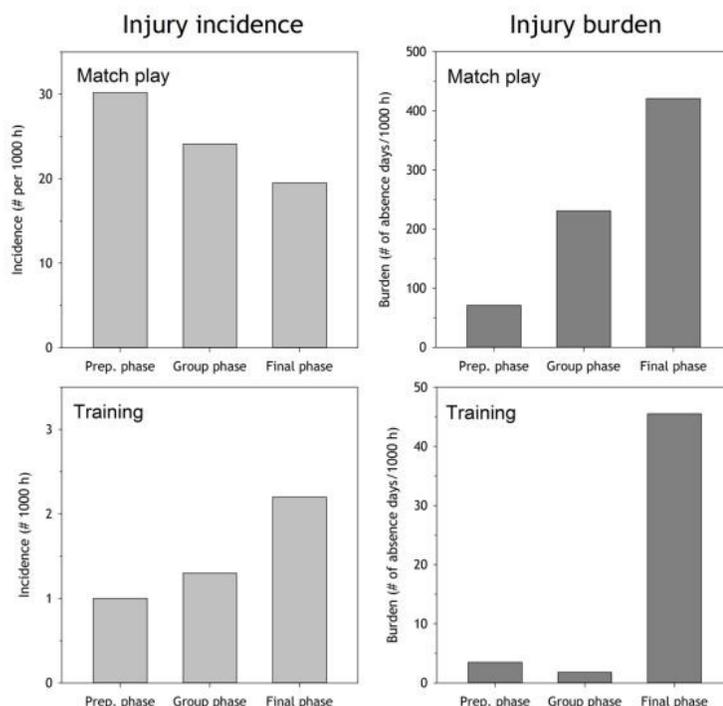


Figure 2 Injury incidence (number of injuries per 1000 hours of player exposure) and injury burden (number of days lost to injury per 1000 hours of player exposure injuries) during match play and training during three stages of the European football championships (Euro 2016), the preparation period, the group phase and the final phase.

The number of lost days (and detraining) among elite athletes can represent a good part of the competitive year. A study conducted in Ireland showed that the average athlete suffered the effects of sports injury for 52 days in a year. More time was lost through overuse injuries than acute injuries. The injury rate per 10,000 hours of participation was lowest in noncontact and explosive sports and highest in contact sports. However, when expressed in terms of days lost per 1000 hours of participation, endurance sports had the lowest burden of time loss and explosive sports the highest (Watson 1993). In terms of the amount of time lost due to injury, elite gymnasts spent 20.2% of the year's training time at less than full capacity, compared with 13.9% for the nonelite gymnasts. (Kolt et al 1995). In a study with collegiate female athletes, during the 12 recorded months, lost-time injuries occurred in 31.4% of the athletes (Walbright 2017). Among Brazilian Jiu-Jitsu athletes, players missed an average of 35.9 ± 60.1 days of practice due to BJJ-related injury in 12 months (Usuki et al 2017).

| Factor | Type of sports | | | |
|--|--------------------|--------------------|--------------------|---------------------|
| | Endurance | Contact | Noncontact | Explosive |
| Participation (hours per year) | 310.5 | 213.7 | 476.4 ^a | 258.1 |
| No. of acute injuries per year | 1.173 | 0.996 | 1.580 ^b | 0.961 |
| No. of overuse injuries per year | 1.061 ^c | 0.766 | 1.136 ^c | 0.751 |
| Days per year with acute injury | 18.68 | 20.20 | 31.96 | 48.79 ^e |
| Days per year with overuse injury | 22.31 | 13.88 | 45.63 ^d | 72.98 ^d |
| Acute injuries per 10,000 hours of participation | 37.81 | 46.60 ^e | 33.13 | 37.20 |
| Overuse injuries per 10,000 hours of participation | 34.15 | 35.85 | 32.17 | 28.06 |
| Days of acute injury per 1000 hours of participation | 60.00 ^f | 94.53 | 95.79 | 189.03 ^e |
| Days of overuse injury per 1000 hours of participation | 70.85 | 64.95 | 95.79 | 282.76 ^e |

^a Significantly different from explosive and contact sports ($P < 0.01$).

^b Significantly different from endurance, contact, and explosive sports ($P < 0.05$).

^c Significantly different from other sports ($P < 0.05$).

^d Significantly different from endurance and contact sports ($P < 0.01$).

^e Significantly different from endurance, noncontact, and explosive sports ($P < 0.05$).

^f Significantly different from contact, noncontact, and explosive sports ($P < 0.05$).

^g Significantly different from endurance, contact, and noncontact sports ($P < 0.01$).

From Watson 1993.

Time lost to acute and overuse injuries over a 12-month period

| No. of days | Injuries | | |
|------------------------|---------------|----------------------------|---------------|
| | Acute | Overuse | All |
| In a hospital | 0.12 ± 0.13 | 0.03 ± 0.07 | 0.15 ± 0.16 |
| Off sports | 12.84 ± 4.51 | 11.78 ± 10.13 | 24.62 ± 13.98 |
| Of restricted activity | 11.58 ± 6.52 | 15.43 ± 13.20 ^a | 27.01 ± 20.02 |
| Total days affected | 24.54 ± 10.22 | 27.24 ± 22.62 | 51.78 ± 32.60 |

^a Significantly different from acute injuries ($P < 0.05$).

From Watson 1993.

Planned Detraining

Planned detraining may not be detraining proper or it may be a training strategy when competing physiological adaptations are involved. This is known as “concurrent training and retraining” and is mostly applied to track and field and team sports (Sousa et al 2019).

Very short term (under a week) training interruption is a part of the training strategy where complete training cessation leads to increased strength.

The exact mechanisms involved are unknown but the strategy has been used intuitively and successfully by powerlifters since there is any record of programming. Recent studies simply confirm that a period of training cessation of a little less than a week is, on average, optimal (Pritchard et al 2017, Pritchard et al 2016).

Much research is needed to start to understand the nature of the beneficial short-term training cessation. A few interesting molecular studies have been conducted and we might have a better understanding of the involved phenomena in a couple of years (Ogasawara et al 2013).

Takeaways

- Detraining is very common for athletes who have been in a sport long enough to call themselves athletes. Although the more experienced and better skilled the athlete, the lower the chances of getting injured, the more time one trains and competes increases the chances of injury and illness.
- Detraining is not the end of the world. Most of the time, retraining will bring the athlete right back to where he/she was. The more accepting you are about it, the better are your chances of recovery.
- Detraining can produce significant damage or not. If it does, it is usually reversible. It is unpleasant but it's part of being an athlete.
- The more damaging the detraining effects, the more work retraining will require.
- Short periods of training cessation have beneficial effects at least for the strength sports.

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