Review

Primum non nocere: A commentary on avoidable injuries and safe resistance training techniques

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Objectives: Recently attention has been brought to potentially unsafe training methods within the practice of resistance training. Thus purpose of this commentary is to highlight the importance of the moral injunction *Primum non nocere*, and of weighing risks to rewards of training methods, for those providing resistance training recommendations and practitioners of it as a training approach.

Design & Methods: Narrative review

Results: It appears that many popular resistance training methods that make use of either explosive movements or unstable platforms with heavy external loading may present an increased risk of injury. In addition they may not offer any greater improvements to measures of health and fitness above safer alternatives that utilise more controlled repetition durations and avoid use of unstable platforms. Indeed, as resistance type and load may not be as important for determining strength or hypertrophic adaptations as previously thought, nor does there appear to be much supporting evidence for the transfer of balance skills developed using unstable platforms to other movement skills, the necessity of such unsafe practices appears further questionable.

Conclusions: It is recommended that persons wishing to engage in resistance training for the purposes of health and fitness whilst reducing risk of injury should utilise a controlled repetition duration that maintains muscular tension and avoid use of unstable platforms. Indeed, practices involving use of lower external loads, or even the absence of external loads such as bodyweight training or isometric co-contraction, may also be effective and may pose an even lower risk of injury.

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INTRODUCTION

The title of the present piece, *Primum non nocere*, is a Latin phrase which translates directly as "*first, do no harm*." A moral injunction of the Hippocratic Oath that all medical providers swear to, it is also something that all healthcare professionals are taught to adhere to. However, with a recent spate of well-publicised and serious injuries stemming from resistance exercise based interventions supposedly aimed at improving health and fitness, its acceptance, or even its awareness, may be lacking in the realm of exercise professionals. This may be an issue both in academic discussion of exercise as well as in practitioner's applications. Thus, the aim of this commentary is to create awareness of this principle amongst trainers and trainees over potentially dangerous exercise programmes, and remind all that 'evidence-based practice' is the key to safe, effective and successful training.

The health benefits of resistance exercise are extensive and well recognised, and whilst motivations to exercise vary between individuals we can generally assume that a priority for western health-care societies should be to improve health, prevent injury and disease and improve physiological fitness parameters (e.g., strength, endurance, flexibility and cardiovascular fitness). As our bodies age there is a natural decline; loss of bone mineral density (BMD), loss of muscle mass and strength and increase in fat mass, ultimately resulting in reduced physical performance.[1-4] In alignment, the *Encyclopaedia Britannica* defines human aging as "*the decline of biological functions and of the ability to adapt to metabolic stress*." As such, with aging there is generally an increased risk of acute and chronic conditions, including greater frequency of bone fractures, obesity, diabetes, coronary heart disease, etc.[5] The authors of the present piece have considered this physiological decline with age and summarised recreational exercise motivation into the following goal; to have a biological age equal to or lower than our chronological age; for example, that we might look, feel and function as well as someone younger than ourselves. Indeed, this is the possibility of correctly performed resistance training: not to slow down aging, but to reverse the aging process. Resistance training in untrained older adults does not merely slow the decline of muscle mass and BMD, it actually increases muscles mass and BMD.[6,7] Succinctly, resistance exercise has been recommended for and

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is evidenced to reduce the risk of all-cause mortality.[8-10] However, when prescribing exercise we should ensure we are *improving* health, not jeopardising the body's function through injury.

EVIDENCE-BASED EXERCISE VERSUS FASHION

Whilst the exercise industry is often rife with fashionable workouts such as *Insanity, CrossFit, P90x* and so on, the reality is that these programmes have a higher potential for injury as a result of their explosive and unstable movements. In such a litigious society, we must ask as to whether participants in these activities are advised to the potential risks associated with these training methods and do they really have greater benefits than safer alternatives?

Two recent reviews considering strength[11] and hypertrophy[12] concluded that there are no benefits to using any specific resistance type (e.g. free weights, resistance machines, body weight exercises, etc.) above any other since muscles have no knowledge of what they contract against. In addition, that the balance required as a result of using free weights or exercising on unstable surfaces offer no greater improvements in strength or hypertrophy and show no evidence of transference to other balance tasks or improvements in sporting movements.[11] The authors also discuss the context of repetition duration and explosive lifting, suggesting that the unloading of a muscle through high-velocity movements reduces muscular tension, a key mechanism for strength and hypertrophic adaptation.[13] A previous review by Bruce-Low and Smith[14] investigated this area citing multiple articles regarding the high prevalence of injury associated with explosive movements; notably that of lumbar spondylolysis as a result of Olympic weightlifting exercises.[15-17]

More recently did Hak et al.[18] publish statistics for the prevalence and significance of injury from *CrossFit* as a training method, summarising its similarities to that of Olympic weightlifting. The authors' statistics indicate that 97 of the 132 responses (73.5%) reported sustaining an injury during *CrossFit* training. Perhaps even more alarming was that 7% of injuries required surgical intervention. Nevertheless, the efficacy of this training method should also be considered. Smith, et al.[19] reported improved aerobic capacity and decreased body fat percentage, as a result of 10 weeks of *CrossFit* training. However, Smith, et al.[19] also commented on the 16% drop-out rate of their research intervention and concluded:

> *"This may call in to question the risk-benefit ratio for such extreme training programs, as the relatively small aerobic fitness and body composition improvements observed among individuals who are already considered to be above average and well above average may not be worth the risk of injury and lost training time."*

In fact, previous reviews of weight-training injuries suggest that the most common mechanism of injury is weights being dropped on a person (accounting for 65.5% of total injuries). Of these, 90.4% were a result of using free weights, which are inherently unstable in nature with 23.6% accounting for fractures and dislocations.[20] Worryingly, as Hak et al.[18] describes, the likes of *CrossFit* training which advocates free weights and explosive Olympic weightlifting, also encourages high numbers of repetitions in as short a time as possible. Olympic weightlifters often perform single repetitions of heavy loads, focused on the intricate skill required to perform such a lift. When we remove this emphasis on technique and apply peer pressure to perform high repetitions when the body is already in a state of fatigue with free weights which have the highest risk of injury, to perform explosive movements which are already high risk we appear to be creating the *'perfect storm'* for injury. With this in mind CrossFit might better be likened to extreme sports which appear to have minimal physiological benefit but retain all the risk elements.

RECENT CASES OF SERIOUS INJURY

As if to reinforce this potential risk, a recent high-profile case resulted in spinal cord injury whilst performing a 'snatch' exercise.[21] A *CrossFit coach* and presumably experienced Olympic weightlifter had his spine severed when he dropped the barbell. At the time of writing this piece, the injured party has *'no voluntary movement below the waist'*. Even an Olympic weightlifter, honing a highly specific skill set required for their sport might consider the risk-benefit ratio of performing such potentially dangerous exercises, let alone someone looking to improve their aerobic fitness and body composition. In fact Bruce-low and Smith[14] have noted that, unless your goal is to improve the ability to perform the specific lifts involved with the sport of Olympic weightlifting, there is no need to perform them over and above more traditional resistance training methods. Junge, et al.[22] and Engebretsen, et al.[23] have reported the prevalence of weightlifting injury in the 2008 Beijing, and 2012 London Summer Olympics. The statistics of 43 injuries from 255 competitors (16.9%: 2008), and 44 injuries from 252 competitors (17.5%: 2012) equate to a 1 in 6 chance of injury, from what we can assume to be the most *SKILLED* Olympic Weightlifters. Whilst we acknowledge that Olympic athletes might be using greater loads that non-elite Olympic weightlifters, the evidence clearly suggests that this is an inherently dangerous activity. Another tragic spinal cord injury occurred in the summer of 2012 to a college football player.[24] This injury occurred in the weights room, not on the football field. On this occasion, it was reported that the athlete was completing 'step-up' exercises with a load on his shoulders. After losing balance and falling, the athlete is now paralyzed. The sad reality of this incident is that the exercise of performing weighted step-ups has no evidence of being any more efficacious than any number of safer exercises, even performing an identical exercise with the load in the hands in the form of dumbbells or kettlebells, both of which would have allowed the athlete to more safely drop the load to his sides if needed.

These examples are not exceptions. Both were experienced trainees performing potentially dangerous exercises. Both injuries were also reported as freak accidents. Unquestionably, the prevalence of this kind of accident is fortunately low, but the potential for this accident with the aforementioned risk factors,

is unnecessarily high. When considering the risk-benefit ratio and evidence base surrounding the efficaciousness of resistance training, this might best be described by the adage; *"There is no right way to do a wrong thing."* A person can improve their strength,[11] muscle size,[12] cardiovascular fitness,[25] and BMD,[7] and decrease the potential for injuries through strengthening their joints, tendons and ligaments[26,27] as well as reduce their risk of all-cause mortality[9] by appropriate resistance training that does not incur the same potential for injury.

Even for the athletes who are willing to take these risks for the prospect of, albeit unsupported, potential marginal gains in their performance, we caution that even a less severe injury might still result in a necessary rest from training to recover properly, which could obstruct future progress. Consider the example of Francisco Garcia, who whilst playing for the Sacramento Kings was injured performing a press exercise whilst resting on an inflatable exercise ball, the *'anti-burst'* ball burst and Garcia was left with a broken wrist.[28] The Kings had recently signed Garcia for $30million, and both the Kings and Garcia sued the manufacturer and settled out of court for an undisclosed amount. This was within a few years of a similar incident where a male trainee was performing a dumbbell press exercise on a stability ball when the ball burst leaving him hospitalised with both wrists broken, a fractured forearm and injuries to both shoulders.[29] We have previously discussed training with unstable surfaces[11] and summarised that training the core appears to have been misrepresented as requiring challenges to balance. Our previous discussion clarifies that balance is a very specific skill and we agree with Willardson[30] who states:

> *"Performing resistance exercises on unstable equipment will make an individual more proficient at performing resistance exercises on unstable equipment but may not enhance the performance of sports skills".*

Since there is no evidence to support the efficacy of resistance training on unstable surfaces, and there is evidence to suggest a higher risk of injury as a result of the instability we urge caution to the use of these potentially dangerous exercises.

By the *Encyclopaedia Britannica* definition, an injured person and/or athlete has prematurely (e.g., not in accordance with their chronology), and albeit temporarily, *aged*. Their recovery and rehabilitation is analogous to an older adult increasing their muscle mass, BMD, etc. However, we should be cautious to group elite athletes with the same motivations as lay persons since the potential risks to athletes through and after retiring from competition are well documented.[31-33] We suggest that athletes might be more prepared to risk premature aging in return for a sporting career. Whereas the general population, who make their living in a school, office, shop or even fitness facility; should have greater awareness of the inherent risks associated with certain types of exercise.

RECOMMENDATIONS

As highlighted, resistance exercise has the potential to improve health and reduce the risks of all-cause mortality if performed properly. When exercising, movements should be of controlled repetition duration with emphasis on producing muscular tension in a good posture rather than lifting a weight in a ballistic manner. Isometric training (static contractions) is a beneficial method of resistance training[34,35] and, as such, time-under-load can be a useful measure of exercise as opposed to repetitions which might promote poor form or explosive movements. Resistance machines appear to have the lowest prevalence and risk of injury although, since there is no evidence to support recommending one resistance type beyond another, bodyweight exercises (e.g. push-ups, pull-ups, etc.; where no additional external load is used) might further reduce the potential for injury. Considering this, improvements in hypertrophy have even been evidenced through the use of isometric co-contractions that do not utilise any form of external resistance and instead involve maximal voluntary contractions of antagonistic muscle groups against one another.[35]

The authors of the present piece empathise with any person injured as a result of exercise yet believe that by discussing the potentially tragic consequences, we can enlighten trainers and trainees of the potential hazards and allow them to consider the risk-benefit ratio relative to their goals and minimise future risk of injury. We would like to clarify that, though *CrossFit* presents itself as a pertinent example, the points raised here apply to any and all exercise methods that utilise inherently unsafe practices. Many other exercise routines have similar risks associated with them and persons should be knowledgeable of the risks of any exercise programme before considering participation.

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