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Article in *Clinical Journal of Sport Medicine* · October 2017

DOI: 10.1097/JSM.0000000000000488

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Risks of Exertional Rhabdomyolysis With Blood Flow–Restricted Training: Beyond the Case Report

Kyle M. A. Thompson, BKin, Joshua T. Slysz, MSc, and Jamie F. Burr, PhD

It is well accepted that physical activity and exercise are effective for improving health, longevity, and physical performance. Therefore, prescribing an appropriate “dose” of exercise is the crucial goal for clinicians, fitness professionals, and coaches who seek to capitalize on the broad (health-related) and specific (performance-related) physiological adaptations induced through targeted physical stress. The challenge, however, lies in the balance of presenting a sufficient stimulus to maximize targeted gains, while simultaneously avoiding excessive stress to any individual body systems, which can result in an aggravation of disease or injury. As this tipping point between beneficial and detrimental stress is both patient/client and situationally dependent, it is often difficult to discern at what point exercise can become a health risk. Like any hormetic response, exercise is likely no different in that the dose is a crucial component of the optimization equation.

As highlighted by Clark and Manini¹ in their recent case report in this journal, blood flow–restricted (BFR) exercise training has gained increasing interest in recent times. Much of the growing interest in this method stems from the fact that it offers the ability for exercisers to use low-intensity exercise protocols that result in similar muscular adaptations as would be expected using relatively higher intensities and volumes. This is especially appealing in situations wherein intense exercise is unwarranted or contraindicated, and there is clear benefit to augmenting the adaptive response to otherwise “low-level” exercise. Precisely because BFR increases the stress of light-load exercise, it is possible that the risk of overstressing the body may disproportionately increase as well. Although the potential dangers of induced ischemia and circulatory or neural complications have been examined and discussed previously,^{2,3} there is less specific literature on the potential of BFR exercise to induce exertional rhabdomyolysis (ER). As such, the case report of Clark and Manini of an ER event occurring during a well-controlled scientific study is of particular interest. Although our group ultimately agrees with the authors’ point that the practitioner must be aware that BFR could induce ER, a severe and sometimes life-threatening condition in which skeletal muscle breaks down after exercise, we feel that the likelihood of this occurrence must be considered in context. At present, there are isolated incidences of ER occurring in conjunction with BFR, and these are highlighted in the literature as case reports brought forth by Clark and Manini,¹ Iversen and Rostad,⁴ and Tabata et al⁵;

however, without context as to the denominator in this equation, we fear that these reports could lead to the false supposition that BFR training creates a disproportionately elevated chance of developing ER compared with other forms of exercise. As such, in line with previous arguments as per the importance of context to interpreting activity risk,⁶ we have searched the available literature to highlight the backdrop against which reported cases may occur.

To date, there is published evidence from 91 studies including 1433 participants in medical/exercise physiology studies using BFR training. Without question, this documented exposure to BFR is a conservative estimate, as it does not include multiple exposures of individual participants (person hours of treatment) or those who are already using BFR training in nonstudy settings wherein exposure is not tracked or reported. Notably, only 3 referenced case reports of ER as a result of BFR training exist, with only the most recent case occurring as part of a controlled trial. This suggests an incidence rate of 0.07% in a controlled environment, and even if the 2 published clinical cases that occurred outside of the noted 1400 participants (and wherein exposure is unclear) are included, the rate is still only 0.2%. Although exposures may differ between this specific form of resistance training and more traditional physical activity, it is interesting to note that the risk of an adverse event while performing BFR training is very much in line with the reported cardiovascular event rates from more general physical activity in adults.⁷ A thorough examination of BFR training–induced complications conducted by a survey in Japanese hospitals, clinics, and training facilities, where BFR (aka Kaatsu) training is more popular than North America, reported a similarly low incidence rate of ER in healthy and diseased populations across varying ages from adolescence to the elderly of ~0.008%.⁸ In comparison, a review of ER cases in athletes contains examples wherein as many as 25% of an American football team, 43% of a swim team, and 435 military personnel developed ER under circumstances of exercising in extreme heat, increased exercise volume, and dehydration.⁹ In these examples, it seems obvious that it is not the exposure to exercise itself but the combination and amount of exercise under specific circumstances which predisposes individuals to developing ER and would therefore be inappropriate to suggest individuals should refrain from these activities. We suggest the BFR-related adverse events likely function in a similar fashion, and the potential risk must also be interpreted in this context.

In the case report of Clark and Manini, the authors pose the question “Does BFR resistance exercise pose a higher risk of ER in comparison with more traditional, high-intensity resistance exercise?” Several examples in which high-volume eccentric exercise and whole-body resistance exercise cause ER are provided, and the authors conclude that exercise intensity may be a key factor in governing the occurrence of ER. We do not dispute that exercise intensity/volume or

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The authors report no conflicts of interest.

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http://dx.doi.org/10.1097/JSM.0000000000000488

induced physical stress resulting from BFR and muscular contraction plays a key role, but we also believe that the importance of other underlying risk factors—or the unfamiliarity of these factors among those who experience an adverse event—should not be overlooked. Because the incidence of these events and the total number of individuals using BFR training are relatively low compared with the number of individuals being diagnosed with ER and participating in other physical activities (team sports, marathons, etc.), it is impossible to come to clear conclusions on which predisposing risk factors resulted in the 3 case reports of ER after BFR training. Although not specific to BFR training-induced ER, rhabdomyolysis as a result of any physical activity is more prevalent when performing high volumes of exercise under compounding physiological demand including exertion in the heat, dehydration, or consumption of specific medications.¹⁰ A detailed examination of risk factors for developing ER is reported by Tietze and Borchers (2014) and includes certain signs and symptoms that the practitioner should be aware of including delayed recovery after exercise, persistent elevated Creatine Kinase (CK) levels, renal injury, family history of ER or sickle cell traits, recurrent muscle cramps, history of heat injury, or serum CK levels >100 000 U/L.

It is our opinion that there is currently a lack of evidence to suggest that the practice of BFR training significantly increases the risk of ER in comparison with any other physical activity; however, we agree with Clark and Manini that the use of low-load exercise does not negate the possibility of ER-related complications, and that the additional stress imposed on the body by the BFR must be considered. Like any exercise, it seems prudent that previous activity levels are taken into consideration before enrollment in BFR training and that prescribed exercise volumes do not abruptly exceed an individual's normal capacity. All of these factors being equal, we would thus suggest that other physiological factors may play a more critical role in the risk of developing ER, especially given evidence that BFR training does not result in greater amounts of muscle membrane disruption when used with 20% 1 repetition maximum loads or during walking exercise (plasma creatine phosphokinase levels <200 IU/L).^{11,12} Just as bouts of intense endurance exercise acutely increase the risk of cardiovascular events such as sudden cardiac death in individuals with underlying risk factors,⁷ we believe that it is the underlying factor and not the exercise itself, which can

acutely increase the risk of ER during BFR training. Therefore, we suggest that individuals must be screened more thoroughly before BFR training. In fact, at least one of the 3 currently published case reports⁵ specifically notes that exacerbation of ER was likely through a combination of excessive stress, bacterial infection, and medication.

It is logical to assume that repeated bouts of BFR training, if performed at the optimal dosage (volume and intensity) with appropriate recovery among exercise bouts, will generate a protective effect against ischemic exercise, or other bodily insult, in a similar way that chronic endurance exercise reduces cardiovascular disease risk factors.⁷ Therefore, we conclude by reminding the readers that risk is always case and context specific and that one size rarely, if ever, fits all.

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