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Whole Body Vibration Training Lowers Serum Creatine Kinase Levels in Boys with Duchenne Muscular Dystrophy

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Abstract

We aimed to describe the effects of whole body vibration training on serum creatine kinase and motor function in two brothers with Duchenne muscular dystrophy using standardized measurements. Whole body vibration was delivered using a side-alternating vibration platform at a starting frequency of 7.5 Hz, increasing up to 20 Hz for 5 minutes three times weekly for three months. The baseline serum creatine kinase of the 7 and 10 years old boys was 33,105 U/L and 14,984 U/L. After vibration training, their levels dropped significantly, reaching a nadir of 7,383 U/L and 536 U/L respectively during treatment. There was a modest increase in their 6-minute walk distance but their overall North Star Ambulatory Assessment scores were unchanged. Whole body vibration appeared to be safe and well-tolerated. The reduction in serum creatine kinase as observed in these two boys suggests a potential benefit of brief high frequency vibration on muscle function.

Keywords: Whole body vibration training; Duchenne muscular dystrophy; Serum creatine kinase

Introduction

Muscular dystrophy refers to a group of genetic diseases associated with progressive muscle weakness and atrophy. Duchenne Muscular Dystrophy (DMD) is a particularly severe and fatal form of this disease, affecting 1 in 3500 live born males [1]. It is caused by mutations in the dystrophin gene leading to a loss of dystrophin [2]. This results in progressive muscle degeneration, wheelchair dependency during adolescence, and death as early as the third decade of life. Currently, there is no cure. Treatment focuses on supportive care and use of glucocorticoids to prolong independent ambulation and to delay the onset of secondary complications [3]. Exercise has long been considered as a potential disease-modifying treatment for muscular dystrophies [4,5]. Studies including the use of animal models have helped to elucidate the importance of using submaximal exercise, the danger of eccentric exercise, as well as the potential safe use of concentric exercise in DMD [6,7]. To date, there are only a few human studies on the effects of exercise in DMD; most studies using submaximal resistance exercises have shown that exercise can be implemented without any harm to the patients [8,9]. The last 10 to 15 years have seen an increasingly unified call to perform additional studies to elucidate the many unanswered questions regarding optimal exercise programs for DMD [3,5,10,11]. Recently, the No Use is Disuse study by Jansen et al aimed to address some of the unresolved issues by examining prospectively the effects of physical training on thirty boys with DMD [12]. The authors concluded that assisted bicycle exercise had a major impact on slowing the deterioration of muscles when compared to controls; they did not however find significant improvements in strength or endurance [12]. The encouraging results supported the need for additional studies to explore alternative forms of exercise for individuals with DMD across different stages of disability.

Current literature suggests that Whole Body Vibration (WBV) therapy via a side-alternating vibration platform may be a valuable method of exercise delivery for patients with a variety of chronic diseases [13,14]. Similar to Jansen et al.'s study [12], WBV training provides a way to deliver a low intensity training exercise which has been shown to decrease pain and improve compliance in the elderly as well as adults and children with cystic fibrosis [15-17]. WBV exercise has also being studied to optimize bone mineral density in DMD [18]. The effects of WBV training on muscle enzymes and motor function however have not been fully elucidated. Therefore, the purpose of this brief report is to describe the effects of WBV training on serum Creatine Kinase (CK) and muscle function in two boys with DMD [18].

Methods

We performed baseline and serial assessments including serum CK measurements, North Star Ambulatory Assessments [19], and timed function tests including the 6-minute walk distance [20] in two brothers aged 7 and 10 years old with genetically confirmed diagnosis of DMD. Both boys were in the ambulatory stage of the disease and were on stable treatment throughout the study period. WBV training was delivered using a side-alternating vibration platform (Vibra Flex®/ Galileo®, Novotec Medical GmbH, Pforzheim, Germany) at a starting frequency of 5 Hz, increasing up to 20 Hz for a total of 5 minutes (2 minutes on, 1 minute off, and 2 minutes on) three times a week for three months (Table 1). Informed consent was obtained from both parents and both boys assented to participation in WBV exercise prior to study commencement.

Results

The baseline serum CK of the 7 and 10 year old boys were 33,105 U/L and 14,984 U/L respectively. The younger brother was steroid-naïve at the start of WBV while the older brother was on stable therapy including deflazacort at 0.9 mg/kg/day since May 2010. After commencing on WBV training, their CK fell in a consistent and

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Week	Frequency	Mode of Delivery	Total Duration
1-2	5-10	1 minute on, 1 minute off, 1 minute on	3 minutes
3-4	15-20	2 minutes on, 1 minute off, 2 minutes on	5 minutes
5-12	20	2 minutes on, 1 minute off, 2 minutes on	5 minutes

Table 1: Whole body vibration therapy protocol for Duchenne muscular dystrophy.

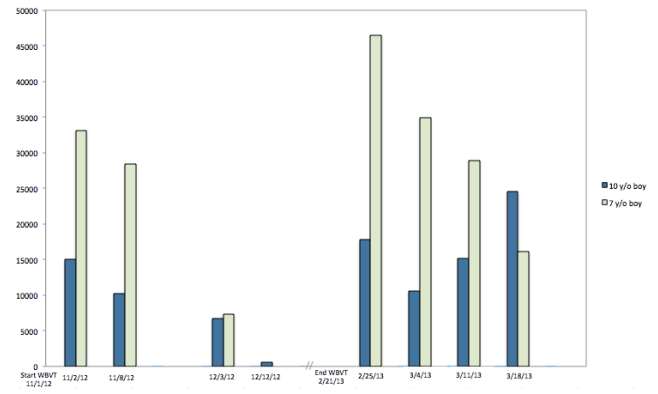

Figure 1: Changes in serum creatine kinase before and after whole body vibration therapy.

stepwise fashion, reaching a nadir of 7,383 U/L and 536 U/L respectively during the second month of treatment (Figure 1). The 6-minute walk distance for the older brother increased from 404 meter at baseline to 448 meter at six weeks on WBV exercise. Similarly, the 6-minute walk distance for the younger boy increased from a baseline of 354 meter to 447 meter. Their overall North Star Ambulatory Assessment scores were unchanged before and after treatment, with a score of 32 and 25 (out of a maximum score of 34) for the 7 and 10 years old respectively. Subjectively the parents reported improved flexibility and increased exercise endurance during WBV therapy. They were willing to come in for all scheduled sessions as it required minimal time commitment, the equipment was easy to use, and the sessions were not physically demanding for the two boys. Aside from transient flushing and increased sweating during the sessions, there were no other reported side effects. One week after completion of WBV training, the serum CK of the 7 and 10 years old boys rose to 46,540 U/L and 17,805 U/L respectively. The 6-minute walk distance was reduced to 376 m in the older brother. After further consultation with the family, the younger brother was started on deflazacort early March 2013; his serum CK came down to 16,108 U/L within two weeks of initiation of glucocorticoid therapy.

Discussion

Historically, WBV exercise was used initially as an attempt to improve the performance of athletes [13]. In theory it works by exposing the muscles to hypergravity [21,22]. The vibration is hypothesized to activate the Ia afferent neurons via stretching force induced by hypergravity; this in turn causes a reflex muscle contraction known as the tonic vibration reflex [13]. WBV exercise has also been proposed to initiate hormonal responses in the body, with increasing serum levels of testosterone and growth hormone reported in men [13,23]. A number of publications have supported the efficacy of WBV therapy [14-18]. Notably, WBV training may be particularly beneficial to those who are physically inactive. Rehn et al. [14] reviewed various studies and concluded that there is moderate to strong evidence to suggest that long-term side-alternating WBV exercise may have a positive effect on muscular performance. He, like other researchers, believed that the inconsistent results among researchers could be accounted for by the variety in vibration parameters (such as frequency and/or amplitude) and exercise regimens (including duration of session and/or number of sessions) [14].

High level of serum CK is a key feature of DMD, related to on-going muscle damage. It decreases steadily with disease progression due to muscle atrophy; the linear decline drops precipitously after the affected individual becomes wheelchair-bound. Absolute levels of serum CK are highly variable among subjects as well as with different age and ethnic background. The average levels for ambulatory DMD boys age 5.9 to 8.7 years old was reported to be 8029 ± 606 U/L for ambulatory subjects and 1986 ± 560 U/L for non-ambulatory subjects age 11.5 to 16.5 years old [24]. Serum CK is widely believed to be a sensitive and specific screening test for muscle disease, and thus it is a useful indicator for studying the potential effects of WBV training on neuromuscular disorders including DMD [25].

As mentioned, the only other study involving the use of WBV exercise in DMD subjects was recently published by Söderpalm et al. in 2013 [18]. This study examined the effect of WBV on bone mineral density as well as on muscle function. The study largely focused on laboratory indicators of bone change, but it did measure changes in serum CK levels on its six participants every three months for a year. Interestingly, the CK levels dropped during the first three months with all of their subjects, though not to the same degree as our two boys above. Over the course of the year, the serum CK levels among participants in Söderpalm et al.'s study rose again, with overall no statistically significant change in CK levels between day zero and 12 months later; there was also no noticeable change in their muscle strength [18]. Additional analysis is required to determine the peculiar decline in serum CK levels that occurred three months into WBV training for both Söderpalm et al.'s study and ours. As a case report, it is difficult for us to draw any definitive conclusions about the long-term impact of WBV exercise and/or whether the results may be applicable to other boys with DMD. As well, additional assessments including evaluations of joint mobility, core strength, and/or endurance will be important outcome measures for subsequent therapeutic studies related to DMD and other neuromuscular diseases.

Conclusion

WBV exercise appears to be safe and well tolerated in ambulatory boys with DMD. The reduction in serum CK and improvement in the 6-minute walk distance as observed in these two brothers on otherwise stable treatment suggests a potentially positive effect of brief high frequency vibration on muscle function. Additional longitudinal studies and/or randomized controlled trials involving a larger cohort will help to determine the role of WBV training as a safe and potentially beneficial exercise strategy for boys with DMD.

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