The Effect of Rebound Therapy on Muscle Tone

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Abstract

This research examines the effect of rebound therapy on the muscle-physiology mechanisms of abnormal muscle tone in neurologically impaired children. Rebound therapy is a severely under-researched area and in desperate need of clinical and scientific explanations for its effectiveness. As the first study of its kind, in an attempt to hypothesise how rebound therapy improves muscle tone, the triangulation of methodologies – namely an interview with an expert rebound therapist, the obtaining of practitioners' opinions of rebound therapy, and observation of neurologically impaired children during rebound therapy – has allowed several hypothesised proposals to be explained in great muscular-physiological detail. These proposals are, in essence from Rollings (2005) who claims that abnormally high muscle tone is reduced because of the vibratory effect on the muscle spindles and that abnormally low muscle tone is increased because of the stimulatory effect upon the sensory systems.

Children aged 2 – 5 years (mean age 4.5 ± 1.4 years) with physical disabilities and abnormal muscle tone were observed during rebound therapy and floor-physiotherapy. The types of work the children did was analysed with reference to information obtained in an interview with a rebound therapy expert. In doing so, the researcher further advocates the use of rebound therapy for physically disabled children, as well as suggesting the underlying mechanisms which may explain why rebound therapy may be beneficial.

The culmination of this study presents the effect of rebound therapy on muscle fibres, specifically explaining how abnormal muscle tone is improved. Decreasing high muscle tone has been attributed to shaking of muscle spindles causing muscle lengthening, changes in compressive forces increasing laxity within the muscle fibres and increased elasticity as a result of the muscle warming up. Increasing low muscle tone has been attributed to the trampolines ability to shake muscle spindles thus demanding their activation, which causes contraction of muscle fibres.

1: INTRODUCTION

There are approximately 65,000 children in the UK who have profound and multiple learning disabilities, many of which are manifested as physical disabilities (Mind, 2006). Children with physical disabilities often develop secondary impairments such as an abnormal level of muscle tone (Goldstein 2005).

Muscle tone can be defined as the tension in a relaxed muscle due to involuntary contractions of its motor units (Tortora and Grabowski, 2003). It is maintained involuntarily, through the activity of the central nervous system. To sustain muscle tone, small groups of motor units are alternatively active and inactive. Abnormal muscle tone is therefore a result of an imbalance between active and inactive motor units, resulting in the abnormal contraction of muscle fibers. Hypertonia is essentially a result of excessive involuntary contractions; hypotonia results from insufficient involuntary contractions.

Muscle tone is fundamentally controlled by activity of the stretch reflex. Muscle spindles that activate stretch reflexes by detecting a change in the muscle length, can be adjusted in terms of how vigorously they respond to stretching, thus setting an overall level of muscle tone. In some neurologically impaired children, the stretch reflex is unable to determine the level and strength of the stretch and the child cannot increase or decrease tone as appropriate during movement.

Having the ability to control muscle tone is imperative: it is essential in maintaining balance, posture and head control, and by varying muscle tone, one can execute fine and gross motor skills efficiently. The effects provoked by an improvement in muscle tone – improved posture and an enhanced ability to move more freely, more efficiently and with greater control – in turn has several beneficial effects to general physical condition and health. Physical inactivity, as a result of being physically disabled, stems further muscle atrophy and joint contractures. Over time, muscles and joints adapt to movement capacity causing deformities and reducing functional capabilities. Movement relieves circulation problems and reduces the build up of pressure sores – these are inevitable problems for physically disabled children during prolonged sitting. Improving muscle tone is of paramount importance for physically disabled children and it can be improved in several ways including surgery and drugs. However less invasively, physiotherapy is a commonly practiced to reduce abnormal muscle tone.

Mayston (2000) highlights the need for the investigation of therapies: they should be based on sound evidence with a solid explanation of their effect. She claims that there is evidence to support some work which therapists do but there are still many unanswered questions. Rebound therapy undoubtedly fits with Mayston's claims.

Rebound therapy is a physical therapy which utilises a trampoline in order to develop and promote motor skills, body awareness, balance, coordination and communication (Rollings 2005). There is no published data into the effectiveness of rebound therapy, and no empirical data to quantify its benefits (Watterstone and Delahunty, 2001; Chartered Society of Physiotherapy, 2002) yet despite this it is commonly used by Special Education Needs schools, as a means of providing movement and physical experiences for those with physical disabilities. It is therefore being done without any scientific evidence.

Rebound therapy is a relatively new physical therapy and there has been very little research done into the therapeutic effects of trampolining for people with profound and multiple learning disabilities (PMLD). As a result, research in this area is very limited (Chartered Society of Physiotherapy, 2002). All of the anecdotal evidence agrees that rebound therapy improves muscle tone, but this is not supported by any scientific evidence (Watterston and Delahunty, 2001).

Rollings' (2005) claims that abnormally high muscle tone is reduced because of the vibratory effect on the muscle spindles and that abnormally low muscle tone is increased because of the stimulatory effect upon the sensory systems. Although these explanations have been taken for granted, neither is based on scientific research: both are based on anecdotal evidence and knowledge in the relevant areas.

This research aims to explain Rollings' (2005) theories by exploring and examining the effects of trampolining on skeletal muscle. Because of this severe scarcity of previously published research, reiterating the relevant skeletal muscle physiology forms an imperative foundation in understanding muscle tone, hypertonia and hypotonia. This information is well documented separately but has never been collated within the context of trampolining. Furthermore, this research aims to triangulate opinion sought from rebound therapy practitioners, information sought from a rebound therapy expert, and information derived from observation of actual rebound therapy sessions and apply this to the relevant muscle physiology to postulate rebound therapy's effect on muscle tone.

2: LITERATURE REVIEW

2.1 DEFINING MUSCLE TONE

Muscle tone is defined as the tension of a muscle due to involuntary contractions of its motor units; it is determined both by the passive elasticity of muscular tissues, the visco-elastic properties of the fibrillary proteins contained within each muscle fibre and by the active (though not continuous) contraction of muscle in response to the reaction of the nervous system (Tortora and Grabowski, 2003; Basmajan, 1979; Wyke 1976; cited in Taylor, Ellis and Haran, 1995). Muscle tone is a result of both muscular components and neural components: it is the tension in a muscle due to the activity of some muscle fibres, and is controlled by the nervous system (Kent, 2003).

Relevant skeletal muscle physiology and the underlying mechanisms of muscle contraction in the control of muscle tone must be first reiterated before examining hypertonia and hypotonia: this is an imperative foundation in understanding why rebound therapy improves muscle tone.

2.2 MECHANISMS OF MUSCULAR CONTRACTION IN THE CONTROL OF MUSCLE TONE

Contraction is activated by a stimulatory nerve impulse from the central nervous system (CNS) (Appleton, 1997). It triggers an action potential which stimulates the muscle fibre, causing it to contract. A muscle fibre is a single, elongated cell which extends the length of the muscle. A muscle is composed of 10,000 to 450,000 muscle fibres (Tortora and Grabowski, 2003): muscle fibre contraction results in muscle contraction.

Myofibrils, contained in copious amounts in muscle fibres, are the contractile element of the muscle (Tricker and Tricker, 1967). They are contained within the muscle fibre cytoplasm and extend the length of the cell (please see Figure 1). Not only can myofibrils contract, but they can elongate to endure stretching of the muscle.

Each myofibril consists of a linked chain of sarcomeres. Sarcomeres contain myofilaments which are chains of contractile proteins. The myofilaments are either thin or thick, and lie in parallel layers, partially overlapping (please see Figures 1 and 2). The thinner myofilament mainly consists of actin; the thicker myofilament mainly consists of myosin.

FIGURE 1: The Relationship Between Muscle Fibres, Myofibrils and Sarcomeres

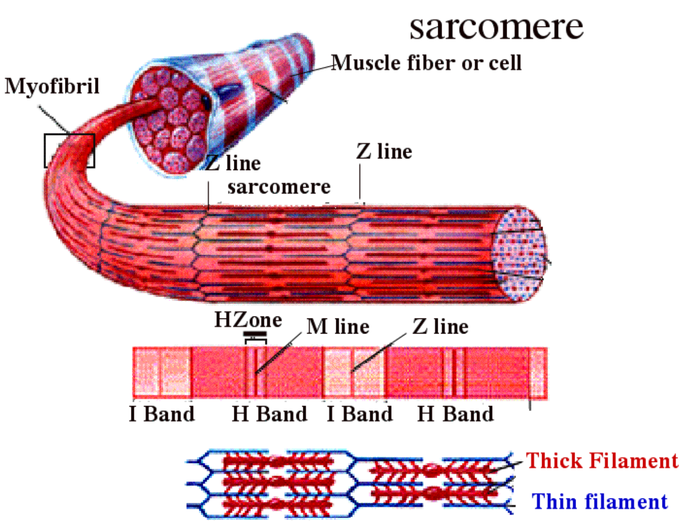


Figure 1: Taken from Matthews (2004)

As proposed by the Sliding Filament Theory (Huxley 1954), muscle contraction occurs because the thick and thin filaments slide past one another increasing the amount of overlap between them (please see Figure 2). Myosin cross-bridges attach onto the actin filament, rotate towards the centre of the sarcomere, and slide the actin filament towards the centre of the sarcomere. The actin layers are anchored to both ends of the sarcomere:

pulling in of the actin filament subsequently draws in the ends of the sarcomere, reducing its length.

FIGURE 2a: A Sarcomere as Proposed by the Sliding Filament Theory – Relaxed Sarcomere

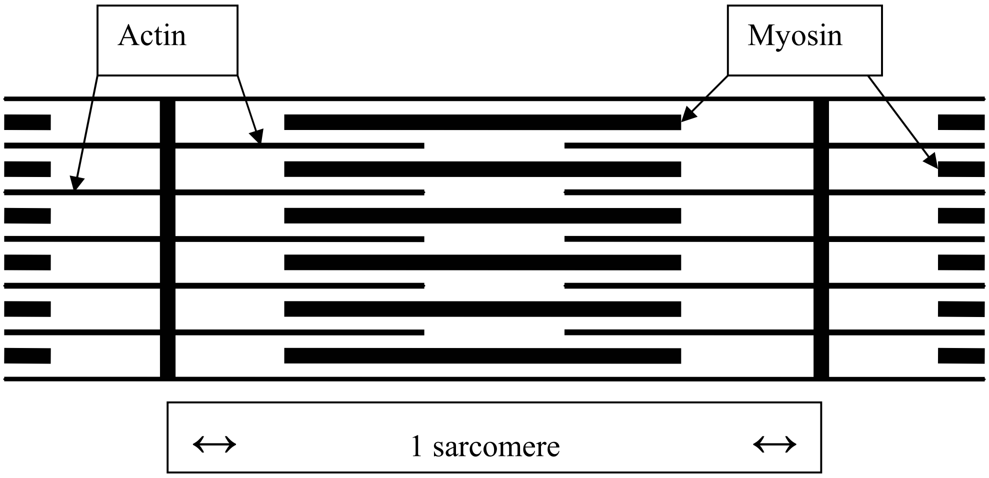
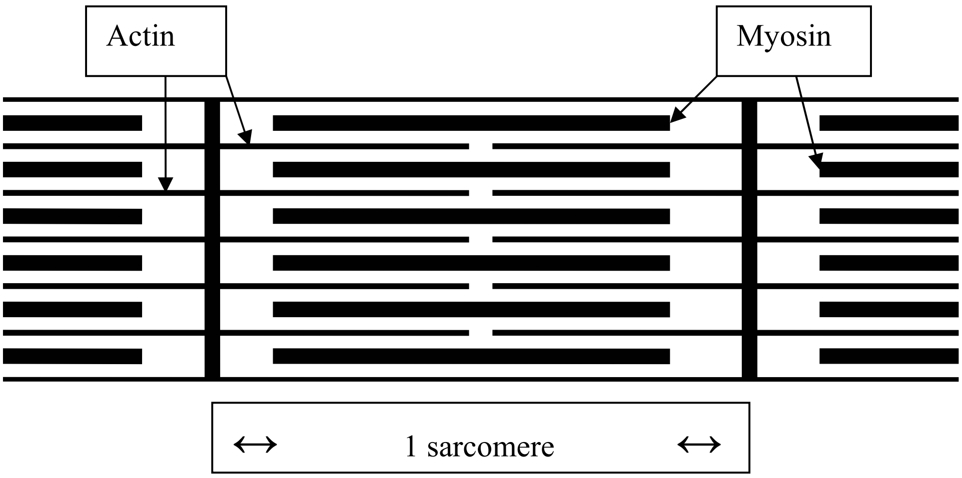


FIGURE 2b: A Sarcomere as Proposed by the Sliding Filament Theory – Contracted Sarcomere



Billions of sarcomeres shortening simultaneously results in contraction of the myofibril and because all myofibrils respond together, this causes contraction of the muscle fibre. Because sarcomeres, myofibrils, and muscle fibres all extend longitudinally within the muscle, the contraction and shortening of sufficient sarcomeres causes the entire muscle to contract and shorten in the same direction. It is this contraction which generates tension: without tension, no voluntary movement could take place (Appleton, 1997). When tension develops, the ends of the muscle are drawn in towards the centre which causes it to shorten and produce movement (Tyldesley and Grieve, 2002). The increase in tension increases tone, which may then instigate movement.

2.3 Maintaining Muscle Tone

When tone is high, bony points move closer together (Ellis *et al.*, 1995) which is also true when observing tension. It can therefore be concluded that increased tension, generated by increased contraction, increases tone.

Muscle tone increases as a result of the increased number of activated myosin cross-bridges (Lee *et al.*, 2005). This increases the proportion of actin filament which overlaps the central myosin myofilament. This results in more contracted muscle fibres which increases tension.

Muscle tone thus results from neural pathways and the CNS, the number of contracted muscle fibres and the amount of overlap between actin and myosin myofilaments. For this reason, it becomes apparent why children with physical disabilities resulting from neurological impairments often have abnormal muscle tone: it is an indirect resultant of abnormal development or damage to motor areas in the brain which disrupt the brains ability to adequately control tone (Cerebra, 2004). Therefore one can postulate that high muscle tone is a result of excessive tension caused by excessive contraction, and low muscle tone is a result of insufficient tension caused by insufficient contractions.

Muscle tone keeps muscle firm but it does not result in a force strong enough to produce movement. At complete rest, a muscle has not lost its tone although there is no neuromuscular activity in it (Basmajan, 1979). When muscles in the back of the neck are in normal tonic contraction, the head is kept upright. To execute fine motor skills, a low degree of contraction is required; to execute gross motor movements, a large degree of contraction is required. Muscles thus need to vary their tone (by varying contraction) at certain times throughout gross movements to ensure smooth movement. The ability to alter muscle tone is therefore very important.

2.4 Hypertonia

Hypertonia, or high muscle tone, is described as an abnormal resistance to passive movement: the resistance has been attributed to muscle, tendon and connective tissue properties and/or the stretch reflex (Carr *et al*., 1995). Hypertonia can be defined as a neuromuscular impairment resulting from increased background motor activity. More specifically, it is a resultant of abnormal excitability of the components of the stretch reflex arc and excessive abnormal and involuntary contractions of muscle fibres innervated by the CNS. Hypertonia restricts movement; if muscles surrounding joints are hypertonus the joint can not move to its full range and if the opposing agonist and antagonist muscles are hypertonus, co-contraction occurs.

In 'normal' muscles co-contraction is prevented by reciprocal inhibition – the process that inhibits a stretch reflex in the opposing antagonist muscle, causing it to relax. The stretch reflex is a reflex contraction of the muscle in response to a stretch (Kent, 2003). Stimulation of stretch reflex receptors – muscle spindles – causes a muscle to contract; inhibition of the stretch reflex – via reciprocal innervation – causes a muscle to relax. Therefore, activation of muscle spindles causes contraction of muscle fibres (Tortora and Grabowski, 2003). The stretch reflex provides a feedback mechanism so that during movement, muscles can adjust length appropriately (Tyldesley and Grieve, 2002).

The stimulus for the activation of muscle spindles is a change in the length of muscle (Tyldesley and Grieve, 2002). Muscle spindles respond to stretch and produce a graded response based on its speed and strength (Carr *et al*., 1995). It is an important mechanism in maintaining muscle tone as it attempts to resist the change in muscle length by causing the stretched muscle to contract: contraction, thus increasing tone, better controls movement. If this reflex is not inhibited or if the reciprocal innervation nerves do not function properly, the opposing antagonistic muscle also contracts following the initiation of movement. As a result, movement is neither smooth nor efficient.

2.5 Hypotonia

There is a scarcity of published work into hypotonia (low muscle tone) (Taylor *et al.*, 1995). Hypotonia is a lack of supportive muscle tone and is usually associated with increased joint mobility (Rollings, 2005). When motor neurons serving a skeletal muscle are damaged, the muscle becomes flaccid (Tortora and Grabowski, 2003). In comparison to hypertonia, which is a result of *excessive* involuntary contraction and activation of myosin cross-bridges, hypotonia is fundamentally a result of *insufficient* involuntary contractions and scarce activation of myosin cross-bridges. As a result, a limited number of sarcomeres are contracted to cause muscle fibre contraction: flaccid muscles cannot generate much tension. Without tension, movement is difficult.

When the body holds a position, muscles are maintained at a constant length by stretch reflex activity. When they change in length, muscle spindles detect these changes and activate the stretch reflex. The level of stretch reflex is modified throughout movement to change the settings of the spindle (Tyldesley and Grieve, 2002) resulting in graded activation: in the first phase of the stretch, the stretch reflex is rapidly heightened to cause immediate contraction (in an attempt to prevent injury); as the stretch is prolonged, the spindle slackens and becomes less sensitive to muscle length changes resulting in the rate of contraction to slow. In some neurologically impaired children, if the stretch reflex is damaged, it results in an inability of the spindle to detect changes so muscle fibres cannot contract appropriately in response to the stretch.

In hypotonic muscles, the muscle spindle is slack and not sensitive to changes in muscle length. This results in slow activation which makes movement difficult. Children with hypotonic muscles often have difficulty in maintaining balance because their postural tone is too low. This is especially true while performing fast and accurate movements (Tyldesley and Grieve, 2002) which can be partially attributed to the delayed activation response. By contrast, in hypertonic muscles, muscle fibres are already excessively contracted and muscle spindles are taut as a result. They are not sensitive to muscle length changes because they are at the height of their activation level (Carr *et al.,* 1995;, Hazlewood, Brown, Rowe and Slater, 1994; cited in Galen and Granat, 1999). Children with hypertonic muscles tend to overshoot movements and have difficulty performing fine motor skills (Tyldesley and Grieve, 2002) which can be partially attributed to the activation response.

2.6 *i* IMPROVING MUSCLE TONE

Coupled with the impaired neuromuscular impairment, children with physical disabilities also face further muscle atrophy due to the overall difficulty in exercising (Goldstein, 2005). When muscles and joints stay at the same length, as they do during physical inactivity, joint contractures occur because muscles and joints adapt to movement capacities. Furthermore, as a result of the abnormal muscle tone and neurological impairment, it is even more difficult for the muscles to stretch. Functional limitations and can occur if deformities are not prevented (Levitt, 1982).

A good level of muscle tone is essential for efficient movement and, by improving the body's ability to increase or decrease muscle tone as required, improvements in posture, head control, balance and fine and gross motor skills will also occur. By improving muscle tone, a physically disabled child will have greater range and capacity of movement which may relieve circulation problems and pressure sores which are provoked by prolonged sitting. Increasing range of physical ability will also reduce opportunity for joint contractures, muscle atrophy and deformities to occur which in turn increases functional capabilities and may contribute to improved quality of life. It is therefore of paramount importance to improve muscle tone.

Muscle tone can be changed by passively stretching the muscle, thus practicing the stretch reflex. This pressurizes the CNS to initiate contraction and respond to the movement. Prolonging the period of stretch causes muscle spindles to habituate which consequently increases the stretch threshold (Appleton, 1994). If stretch reflex inhibition does not occur, co-contraction occurs which is painful.

Conventional physiotherapy for children concentrates on the improvement of gross motor functions such as balance, crawling, sitting, standing and walking (Hallam, 1997). Physiotherapy can be painful and is often hard work. Many adjunctive therapeutic activities have been developed as alternatives to traditional physiotherapy (Harris 1978; cited in Cherng *et al.*, 2004).

2.6 *ii* Hydrotherapy

Hydrotherapy is the therapeutic effect of water to treat and aid a variety of conditions, mainly within areas involving the skin, muscles and nerves. It has been claimed to positively impact the motor development of young children (Stein, 2004).

The benefits of hydrotherapy are based on the water's mechanical and thermal effects, exerting a stimulatory pressure to the skin: the feeling of water on the skin may stimulate skin receptors and nerves which increases blood flow and lessens pain sensitivity. Muscle spindles may be stimulated in the same way. The constant feeling of water massaging the muscles may arouse slack spindles in hypotonus muscles resulting in increased tone.

Hydrotherapy uses the beneficial effect of buoyancy which puts less mechanical stress on the joints than in land based exercises (Kent, 2003; White, 1995). The body's buoyancy enables children to move independently. Combined with the reduction in gravity, the buoyancy decreases compressive forces on weight bearing joints which may aid relaxation, decrease muscle spasm and muscle tension (Koury, 1996; White, 1995). High muscle tone may therefore be reduced because there are less compressive forces pressurizing muscle fibres. The warm water also facilitates a decrease in muscle tension because it dilates blood vessels, increasing blood flow to the skin and muscles.

2.6 *iii* Therapeutic Horseback Riding

It is hypothesized that therapeutic horseback riding benefits children with motor disorders e.g. cerebral palsy, because of the rhythmic, three-dimensional movement of the horse's walking which replicates the movement of a human pelvis during walking, thus providing a normal sensorimotor experience (Quint and Toomey, 1998; Riede 1985; cited in Pauw 2000).

Furthermore, riding horseback continuously changes the relationship between the rider's centre of mass and their base of support therefore improving coordination and challenging balance (Cherng *et al.,* 2004). This is further facilitated by changes in the horse's stride, velocity and direction which demands stimulation of righting and equilibrium responses (Cherng *et al*., 2004; Pauw 2000). Balance is defined as the making of postural adjustments necessary to maintain the alignment between the body's centre of gravity and the base of support (Reid, 1997; cited in Knox, 2002). It is maintained by reflexes involving the eyes, structures within the ears, pressure receptors in the skin and muscle spindles (Kent, 2003). These reflexes communicate via the CNS and brain to cause increases and decreases in muscle tone (to avoid losing balance): it is therefore dependent on the integrity of muscle tone to respond to the CNS and adapt accordingly. Understandably, neurologically impaired children find balancing difficult.

The position of the pelvis plays an important role in efficiency of movement as it influences the position of the lumbar spine which affects thoracic and cervical alignment, thus influencing the position of the head and limbs (Quint and Toomey, 1998). Muscle tone is important to keep the body in alignment (Tyldesley and Grieve, 2002) and so the inability to align oneself may also be equally due to abnormal muscle tone. Quint and Toomey (1998) found that cerebral palsied subjects who rode a mechanical saddle, thus replicating horse riding, significantly increased their passive range of antero-posterior pelvic tilt compared to those who sat on a static saddle. However both groups of children increased their range of pelvic movement, which suggests that the astride position (flexion and abduction of the hip joint) may also contribute to the benefits, rather than the rhythmic, three-dimensional movement alone. They deduced that the pelvic movement hindered hypertonia.

Sitting positioned with the hips abducted reduces electromyogram (EMG) activity in the hip adductors, knee extensors, plantar flexors and back extensors (Quint and Toomey, 1998). A reduction in electrical activity in muscles may indicate a reduction in the neural factors contributing to muscle tone. The astride sitting posture in THR – where the hips are flexed and abducted – may therefore reduce hypertonia. There is no objective evidence which demonstrates that THR improves muscle tone, but Bertoti (1988; cited in Cherng *et al.*, 2004) subjectively concluded decreased hypertonicity in his spastic cerebral palsied subjects. However, a study which examined the effect of THR on muscle tone in the hip adductors using the modified Ashworth Scale, found no significant improvement (Cherng *et al.,* 2004). The studies did show improved standing posture (Bertoti, 1988) and improved walking ability when measured using the Gross Motor Function Measure (Cherng *et al.*, 2004), which improved muscle tone may have contributed to.

2.7 Rebound Therapy

Rebound therapy may benefit children with physical disabilities for many of the same hypothesized reasons as therapeutic horseback riding and hydrotherapy. It can provide an unstable surface, provoke feelings of weightlessness and induce a rhythmic, three-dimensional movement.

Similarly to THR, rebound therapy provides constant opportunity for sensory integration of kinesthetic, visual, and vestibular input. The vestibular sensory system, which responds to changes in head position, body movement and the pull of gravity, is heightened in rebound therapy because of the vertical motions of the body on the trampoline (Rollings, 2005; Noda *et al*., 2003).

Noda *et al*., (2003) reported noticeable improvements in the clinical conditions of permanent vegetative state patients following musicokinetic therapy (passive trampoline bouncing to music). They attributed the improvements to stimuli simultaneously activating vestibular, somatosensory and motor pathways and functions within the brain. This is consistent with the hypothesis that such stimuli from the environment could help restore awareness (Noda *et al*., 2003). This suggests that rebound therapy can also heighten awareness and brain activity for neurologically impaired children, and this effect may be further exaggerated as they can take in more sensory information than the permanent vegetative state patients.

In a pilot study which – and by the authors own admissions was 'born out of the frustrations for a lack of evidence available to support rebound therapy' – investigated the use of rebound therapy for patients with learning disability, it was concluded that the therapy's is an effective means of improving physical disability (Watterston and Delahunty, 2001). The research monitored and evaluated physical condition of five patients over eighteen months, using a five area function assessment which was tested before and after the rebound therapy course. All individuals made progress and there was a 41% group average improvement in physical condition. Because the participants were not experiencing any other therapy, this adds further support for the use of rebound therapy. The function assessment evaluated subjects in transfer onto the trampoline, and ability to sit, kneel, stand and bounce. This was assessed using a five point scale but in criticism of the research, a ceiling effect limited the results.

In a preliminary study which highlighted the benefits of rebound therapy, Hartley and Rushton, (1984) reported remarkable improvements in cerebral palsied children's physical conditions. The study's methodology was observational: with no previous research claiming 'best practice', the therapist-researchers relied on trial and error to monitor the program and responses of twenty-four children, all with similar motor function problems. The children received twice weekly rebound therapy for six months. The research found that rebound therapy reduced hypertonia, but made no claim as to its effect on hypotonia. All results were based on subjective observation and muscle tone was measured by 'feel'. This opens the research up to criticism regarding researcher bias and lack of statistical evidence to demonstrate its improvement.

In hemiplegic children, weight bearing on the effected side improved, and body awareness and posture improved. In spastic quadriplegic children, Hartley and Rushton, (1984) reported reduced adductor spasm, increased range of pain free adduction and diminished symmetrical tonic neck reflex. Furthermore, all children showed an improvement in trunk and pelvis control, and equilibrium reactions and balance. However, in a study which examined balance training in hemiplegic patients, the use of the trampoline was reported not to offer any special advantages to balance mechanisms (Era *et al*., 1991).

The astride sitting position in THR has been concluded to reduce muscle tone in hip adductors, knee extensors, plantar flexors and back extensors (Quint and Toomey, 1998). In addition, this sitting position combined with a rhythmic, three-dimensional movement, significantly improved pelvic range of movement when compared to sitting statically in the position (Quint and Toomey, 1998). Rebound therapy can replicate these beneficial conditions by sitting astride a soft-play cylinder roll whilst being bounced. Furthermore, adjustment to the horse's movements leads to an improvement in joint mobility, muscle elasticity and strength (Pauw, 2000) which suggests that the trampoline's unstable surface may also contribute to improved joint mobility, muscle elasticity and strength.

The pleasant and beneficial feeling of weightlessness reported in many hydrotherapy studies is also simulated in rebound therapy: the therapist can push the bed from underneath a child thus pushing them into the air (Rollings, 2005). Feeling weightless is not only euphoric, but puts less pressure on the joints than in land-based exercises. Similarly to water, the bed allows independent movement. The stimulatory pressure to the skin, induced by the trampoline bed may stimulate nerves which may increase blood flow and lessen pain sensitivity.

The stimulatory pressure to the skin may also increase low muscle tone: Rollings (2005) claims that tone is increased because of the stimulatory effect upon the sensory systems. The repetitive changes in pressure to the skin resulting from repetitive bouncing, may stimulate muscle spindles. The increased sensory stimulation heightens awareness in the brain and CNS which may result in more impulses to be innervated. Rollings (2005) further states that abnormally high muscle tone is reduced because of the shaking effect on the muscle spindles. When muscle spindles are taut, as they are in hypertonia, impulses to the muscle fibres are continually being innervated as activation of muscle spindles causes contraction of muscle fibres (Tortora and Grabowski, 2003). Therefore, by reducing activation of muscle spindles, contraction of muscle fibres may be reduced.

2.8 SUMMARY

Muscle contraction occurs when myofilaments, deep within the muscle contract. In neurologically impaired children, high muscle tone results from excessive contraction; low muscle tone results from insufficient contraction. Furthermore, the ability to change muscle tone – as required to maintain stability – is also often impaired. Because improved muscle tone is essential to general physical condition, improving muscle tone is paramount.

There is a dearth in literature on rebound therapy, but by reviewing other physical therapies, insight into the possible explanations for its effect has been gained: it has the ability to provoke feelings of weightlessness, and can provide a rhythmic, three-dimensional movement and an unstable surface. It is hypothesized to reduce abnormal muscle tone by repetitively shaking the muscle spindles: this has a two way effect and can decrease high tone or increase low tone.

3: METHODOLOGY

3.1 PARTICIPANTS

Approval to conduct research with children was gained from Leeds Metropolitan University, following the consideration of all ethical issues related to working with children. A Special Education Needs (SEN) school hosted the research. Written consent was gained from the head teacher which allowed for the student's release from University. After discussions with the school's deputy head teacher, children in the Nursery and Reception class were chosen to be observed: at this age the potential for learning is greater so children exhibit the steepest improvements in physical condition.

Written consent from the staff of the Nursery and Reception class was obtained, followed by written consent from the children's parents. Because of their severe developmental delay, it was not appropriate to gain informed consent from the pupils themselves.

Eight school-based staff were involved with rebound therapy and physiotherapy. Each received a letter outlining the research aims and explaining their rights as participants. Fifteen letters and consent forms were distributed to parents. The letters explained the nature of the research and asked if their child could be observed during rebound therapy and physiotherapy. The letters emphasized that the researcher had approval for the research from all staff involved, would be working under the supervision of the class teacher or the deputy head teacher at all times and would not be interfering in the lesson in any way.

It was made clear that the sessions would be video-recorded but this would only be seen by the researcher and would be destroyed when the Dissertation mark was published. Participant's rights were made explicit and contact details were provided for both the researcher and her Dissertation supervisor (please see Appendices 1 and 2).

The children in this study – all having complex special needs and being less than six years old – are especially vulnerable and so extra ethical issues were considered. It was emphasized to all adults involved that children would remain anonymous at all times, treated sensitively throughout, their data would be kept confidential, and the researcher would be working under the supervision of the class teacher or deputy head teacher at all times.

TABLE 1: A Summary of the Children's Disabilities

Name	**Sex**	**Age (years)**	**Disability details, taken from each child's IEP**
HI	M	5	Cerebral palsy – quadriplegia Low muscle tone
IT	M	5	Possible cerebral palsy – quadriplegia Low muscle tone
AM	M	4	Cerebral palsy – left side Hydrocephalus
BL	F	4	Microcephaly Generalised low muscle tone, some increased tone on right side Joint hyper-mobility
NU	M	4	Low muscle tone Reduced head and trunk control
YO	M	2	Cerebral palsy – quadriplegia, left side more affected than right side Low muscle tone and hyper-mobility at ankle joints Hydrocephalus

Nine signed parental consent forms were returned and six children were selected to be observed who all matched the criteria of having some form of physical disability and an impairment to muscle tone. As the research focuses on how rebound therapy improves muscle tone, *abnormal* muscle tone in observed pupils was seen as integral. Four of the six children also had physiotherapy sessions, which were also observed. Comparisons were then made in the types of work that the children did in each therapy and their enjoyment in each.

The children's ages ranged from 2 – 5 years (mean age 4.5 ± 1.4 years). Included is a summary of the children's disabilities (please see table 1). All details are taken from each child's most recent Individual Education Plan (IEP). This is a document planning all of the child's differentiated teaching requirements needed to help the student achieve identified targets.

The deputy head of the school was interviewed to provide the research with an in-depth outlook of rebound therapy from a highly skilled and highly experienced practitioner – the participant has twenty-four years of experience in rebound therapy.

His opinion was sought regarding why rebound therapy benefits children with PMLD and specifically how rebound therapy affects muscle tone. Once analysed, the interview proved to be integral to the study: great insight was gained from an expert and this not only formed a firm basis in answering the posed question, but provided further information to investigate the science behind rebound therapy.

As a methodology to obtain specific and in-depth information, interviews are most efficient: the provision to achieve research aims is great. By interviewing an expert in rebound therapy, highly knowledgeable and highly reliable responses were obtained which forms the basis of the Dissertation's answer.

To gain insight into practitioners' opinions of rebound therapy, questionnaires were administered to staff members of the school. General consensus in this school is that rebound therapy is very beneficial for their pupils: most children participate weekly or fortnightly as part of physiotherapy.

Staff included the head teacher, the deputy head teacher, senior teachers, teachers and teaching assistants. Pilot questionnaires were administered first, and following analysis and improvement, revised questionnaires were administered.

3.2 PROCEDURES

Observation lasted four weeks. Pilot sessions of one rebound therapy session and one physiotherapy session highlighted few problems. The battery in the video camera (Sony Handycam) ceased to work after thirty minutes despite being fully charged. Keeping the video camera plugged in at all times overcame this problem.

It was arranged in advance with the class teacher to record the rebound therapy and physiotherapy sessions. In the Nursery, physiotherapy took place in the classroom and children who did not receive physiotherapy were taken out to reduce distraction. The session took place in an area which is carpeted and semi-enclosed (please see Appendix 4: plate i). Various lighting effects combined with fairy lights, disco balls and coloured voile transformed the area into a colourful haven. As the children exercised, they sang songs which were all interactive for each child who, in accordance with the lyrics, got to feel puppet-animals, ice packs and hot packs and were sprayed with water. This multi-sensory approach makes physiotherapy more fun.

All children received one-on-one support in addition to the physiotherapist who directed the session. Each child progressed through set exercises in accordance with their needs and they move around the equipment in a circuit-like fashion. The group used several pieces of apparatus including small benches for box sitting, triangular wedges for long sitting, cylinder rolls and the back rests of small chairs which were used as a balancing aid when standing (please see plate Appendix 4: plates i-v).

In reception class, physiotherapy took place in the Soft Play room where the rest of class were also playing (please see Appendix 5a). Only one child received physiotherapy but the presence of his classmates made it seem more like play. Although the session was only observed once, making generalisations about this pupil's physiotherapy is difficult, but the exercises he did on this occasion and his responses to the work can be analysed.

Rebound therapy for both classes took place in the school's hall. There were always two adults with one child on the trampoline and spotting (the close supervision of staff around the trampoline perimeter) was not necessary as the children were non-ambulant and did not leave contact with the bed or the supporting adult.

Several pieces of equipment were used in rebound therapy to enhance and accentuate the benefits. Similarly to physiotherapy, cylinder rolls, which vary in size depending on the size of the child, were used in a variety of ways.

All observed sessions were transcribed to summarise the session in paper format (please see Appendix 5 a-f). The length of time the children spent on each exercise was noted so that it could be analysed later. In the nursery, the maximum number of therapy sessions observed was three. For the child in reception class, only one session of each therapy was observed.

The interviewee was contacted by telephone and the interview was arranged at a time suitable for him. Before beginning the interview, the participant was given a letter and a consent form (please see Appendix 6). The letter outlined his rights as a participant and made explicit that although he would remain anonymous, any responses he gave may be used in the study.

The interview was recorded in the subject's office to minimise interruption and background noise. A semi-structured interview was used so that all information set out to obtain *was*, but insightful information not foreseen, could be explored. It was recorded onto audio tape (Olympus Mircocassette™ Recorder) which was then transcribed and analysed (please see Appendix 3).

There is no published questionnaire which enabled opinions of rebound therapy practitioners to be sought, and therefore an original questionnaire was created. It aimed to ascertain opinions regarding the most significant benefits of rebound therapy, how does rebound therapy compare to hydrotherapy, how evident are the benefits and to what extent does rebound therapy benefit children with PMLD.

Discussions with the school's deputy head teacher lead to the compilation of a list of staff suitable to fill in a questionnaire. It consisted of staff who regularly did rebound therapy, were experienced in rebound therapy or qualified rebound therapists.

From this list, five members of staff were selected to complete a pilot questionnaire. Although this is a low number, it was considered appropriate to the total number of suitable staff. In order to gain a greater critical analysis of the pilot questionnaire, it was arranged in advance to sit down with the participant while they completed it.

The results of the pilot questionnaire highlighted several areas which needed amendment. The first issue which arose showed that participants found it difficult to make generalisations between any two children, even if they have the same diagnosed disability: the disability could exhibit itself more or less profoundly and encompass diverse sub-conditions. Furthermore, participants were concerned that rebound therapy was more beneficial to some children than others, benefits children in different ways and the effects of rebound therapy manifest themselves differently in different children. Only being able to tick one or two of the most significant benefits, was thus an injustice.

In an attempt to resolve these concerns, the revised questionnaire asked participants to describe rebound therapy for the children that they work with, allowing participants to focus on a smaller group of children.

A further issue which arose was that the effects of rebound therapy change over time, and this time period was not specified. Similarly, environmental context was also questionable which is why short and long term had to be adequately defined.

Following the pilot questionnaire, twenty two revised questionnaires were administered at a time deemed most suitable for the members of staff e.g. before 8.50AM, at break time, lunch time or after 3.10PM. Questionnaires were given out with a covering letter (please see Appendices 7 and 8) which explained the aims of the research, the aim of the questionnaire, made explicit all of the participant's rights and which included contact details for the researcher and her supervisor.

Due to time constraints for the participants, it was not appropriate to sit down with them as they completed the questionnaire, but were told where the researcher could be found in case of any questions or problems.

3.3 Data Analysis

Observation of children served two functions. Primarily, it gave the researcher a greater insight into the practicalities of rebound therapy and secondly it allowed for a specific analysis of how and why the exercises performed on the trampoline improved muscle tone. This latter analysis incorporated all of the scientific underlying principles associated with muscle physiology and data collected from the interviewee, who explained how rebound therapy works. The culmination of this proposed scientific answer could then be applied to the children's rebound therapy sessions that had already been recorded. This ultimately allowed the application of theory into practice.

Furthermore, observation of the children during their physiotherapy sessions allowed for comparisons to be made in the types of work the children did in physiotherapy and rebound therapy and their enjoyment in each. Data was analysed in terms of how often the children received rebound therapy and physiotherapy, how long sessions lasted for, what types of exercises the children did, the progression of exercises through the session, what equipment was used and whether the children enjoyed the sessions.

The data collected in the interview was analysed with the aim of discovering how rebound therapy benefits children with PMLD and, specifically, how it improves muscle tone. The subject was asked how rebound therapy compares to hydrotherapy and floor-physiotherapy, how effective is rebound therapy, how does rebound therapy work, and what effect does the equipment used have.

His answers were used in discovering how rebound therapy improves muscle tone but furthermore, previously unknown underlying scientific principles, not discovered from observation of practical sessions but brought to light during the interview, were researched and collated with other underlying scientific principles, thus adding to the detail of the answer to how rebound therapy improves muscle tone.

Twenty two questionnaires were administered; twenty one were returned producing a response rate of 95.45%. One questionnaire was discarded for being inadequately completed.

Questionnaires were analysed to gain deeper knowledge of the opinions held by rebound therapy practitioners: how rebound therapy compares to hydrotherapy, if they know how rebound therapy works and what the most significant benefits are to children with PMLD. However, the primary aim of the questionnaire was to ascertain the opinions held by practitioners regarding the immediate effects of rebound.

4: RESULTS

4.1 OBSERVATION

The data for the observations outlining the actual exercises can be found in Appendices 5:a-f. They were analysed with the intention of establishing:

- how often children received rebound therapy and physiotherapy
- how long sessions lasted for
- the progression of exercises through the session
- what equipment was used
- whether the children enjoyed the sessions
- how and why the exercises performed on the trampoline improved muscle tone

Children in the Nursery experienced rebound therapy and physiotherapy once a week; in reception class the pupil received rebound therapy and physiotherapy once in three weeks. However other forms of physiotherapy and movement experiences take place daily and throughout the week which were not included here. The average amount of time spent on the trampoline was 14.23 minutes (± 2.66). The average time children spent in physiotherapy was 44.33 minutes (± 6.27).

In rebound therapy, various stances were executed and adapted for each child's needs. Typically, the children did the exercises listed below (please see Table 2 and Appendix 9), however, due to variances in physical abilities and disabilities, children did not do all exercises.

Progression was observed during all sessions as exercises were adapted to promote more independence and further develop skills. By examining the exercises for each child in Appendices 5:a-f, this progression becomes apparent, however it is not integral in answering how rebound therapy improves muscle tone and so it has been omitted.

TABLE 2: Exercises and Positions in Rebound Therapy and Physiotherapy

Rebound therapy	Physiotherapy
Cross legged sitting	Box sitting
Long sitting	Long sitting – on floor
Supine	Long sitting – on wedge
High kneeling	High kneeling
Four point kneeling	Four point kneeling
Standing	Standing
Rolling in prone over roll	Rolling in prone over roll
Sitting astride roll	Sitting astride roll
Massage	Specially adapted bike (Pony Walker)
	Massage

Several pieces of apparatus were also used in rebound therapy and physiotherapy (please see Appendix 4: plates ii-v). The equipment served several purposes although primarily it acted as physical support and ensured correct positioning. This has been outlined in Table 3.

The children's enjoyment in each activity was also noted. From the predominant smiles, one would conclude that all children enjoyed rebound therapy and that most children enjoyed physiotherapy most of the time. During physiotherapy, children appeared to be less motivated and a few children cried: no crying was observed during rebound therapy.

TABLE 3: Equipment used and Basic Rationale for its Use

Equipment:		**Rationale**
Box		Ensures hips, knees, ankles are at 90º angles
Small chair		Balancing aid
Cylinder roll:		
Horizontal	Sitting astride	Stretches hip adductors Provides good sitting position Reduces the need to concentrate on the whole body by isolating part of it, the child only needs to concentrate on the upper torso Stimulates balance and postural reactions
Horizontal	Prone four point kneel	Provides trunk support
Horizontal	Prone high kneeling	Provides trunk and arm support
Vertical	Standing	Balancing aid
Slip mat		Prevents children putting fingers and toes in the webbed bed Prevents gastrostemy pegs or tracheostomy getting caught
Triangular wedge		While long sitting, reduces the amount of stretch on the hamstrings

4.2 INTERVIEW

The data collected in the interview provided a solid and reliable foundation to better answer how rebound therapy improves muscle tone: the interviewee, as an expert of rebound therapy, is clearly knowledgeable so any conclusions made from this data are assumed to be highly accurate. Key themes which explain why muscle tone is improved have been summarised in Table 4. This provided the necessary stimuli for further research to better answer the posed question.

The interviewee explained that high muscle tone is decreased as the bed vibrates which consequently vibrates the muscle spindles. This causes muscles to lengthen thereby reducing tone. Furthermore, the aerobic exercise induced by bouncing provokes increased blood flow which increases the amount of oxygen available to the muscle; combined with the increasing muscle temperature increasing elasticity, tone is reduced. He also explained that low muscle tone was decreased because the vibrating bed stimulates the muscles, forcing them to react against the surface. This 'forced reaction' causes muscles to increase in tone (Appendix 3).

The main focus of this research was how rebound therapy improved muscle tone but the reasons why other benefits arise in rebound therapy were also extracted and provided foundations in discussing rebound therapy's value (please see Table 5). The data conveyed in Tables 4 and 5 has provided a firm and reliable foundation to how rebound therapy improves muscle tone, which when combined with the reviewed skeletal muscle physiology, can be specifically answered and explained.

TABLE 4: Attributions for Rebound Therapy's Effect on Muscle tone

High muscle tone	Low muscle tone
Gentle movements vibrates spindles – lengthens muscles and decreases tone	Tapping effect stimulates floppy muscles – become firmer
Movement warms up muscles – more oxygen – more elasticity	Vibratory effect forces muscles to react against trampoline
Children feel more supported on the trampoline than on the floor – solid, flat surface of the floor does nothing to help curb spasms and reflexes	Children do not feel as heavy on trampoline compared to on the floor – solid, flat surface of the floor provides nothing to absorb the heaviness, trampoline bed does absorb some

TABLE 5: General Attributions for why Rebound Therapy Benefits Children with Profound and Multiple Learning Disabilities

As a result of the moving bed, balance mechanisms within brain are forced to react
Increased kinesthetic feedback
Increased proprioception
Gravity
Compressive forces
The feeling of weightlessness
Increased blood flow to extremities
Increased vestibular feedback
Newton's Laws of Motion

4.3 QUESTIONNAIRE

Of the staff questioned, 55% are regularly involved in rebound therapy: most members of staff work with less than five children, which is representative of the high staff to pupil ratio. All respondents agreed that rebound therapy benefits children with PMLD.

Participants were asked how much impact rebound therapy has, and to what extent does rebound therapy benefit children with PMLD. Both questions were sub-categorised to establish any differences between short term i.e. the hours following a session, and long term i.e. the extent to which rebound therapy contributes to general physical condition (please see table 6).

The mode average response was assumed as average opinion. The results therefore indicate that in practitioners' opinion, rebound therapy has considerable impact in the short term, and significant impact in the long term. In the short and long term, the benefits of rebound therapy exhibit themselves very apparently i.e. they are very obvious.

40% more participants selected this response (“very apparent”) than any other response, heightening further support for this claim.

Hydrotherapy is more commonly practiced in paediatric physiotherapy because it is known to benefit children with PMLD and – and unlike rebound therapy – is supported by scientific evidence. It is has thus, in the researchers opinion, formed the foundation for adjunctive therapies in terms of how valuable it is. This suggests that rebound therapy should be directly compared. Therefore, the same questions were also asked about hydrotherapy: the extent to which hydrotherapy benefits children and how apparent the benefits are (please see table 6). All participants agreed that hydrotherapy benefits children with PMLD.

The results show that in general opinion, in the short term, the benefits of hydrotherapy are very apparent and it has a significant impact. In the long term, hydrotherapy has considerable impact and the benefits are very apparent.

There is little difference in how practitioners rate rebound therapy and hydrotherapy and their effects on children. In the short and long term, practitioners claim that the benefits of these two therapies are very apparent i.e. the effects are very obvious. Participants agreed that rebound therapy has greater impact on children in the long term but hydrotherapy has greater impact on children in the short term.

The results highlight the importance of rebound therapy from the members of staffs’ points of view. It compares well to hydrotherapy, which is more commonly practiced: rebound therapy apparently has more significant long term impact on general physical condition.

TABLE 6: Respondents' Opinions of Rebound Therapy and Hydrotherapy – Expressed a as a Percentage

		Rebound therapy			Hydrotherapy	
		Short term	Long term		Short term	Long term
		Percentage of respondents				
To what extent does the therapy benefit children with PMLD:	Little to no impact	**0**	**0**		**0**	**5**
	Moderate impact	**35**	**5**		**25**	**10**
	Considerable impact	**40**	**40**		**35**	**45**
	Significant impact	**25**	**55**		**40**	**40**
How apparent are the benefits of therapy:	Marginally	**15**	**5**		**0**	**5**
	Quite apparent	**20**	**15**		**20**	**25**
	Very apparent	**60**	**60**		**60**	**40**
	Extremely explicit	**5**	**20**		**20**	**30**

A list of the most popular cited benefits of rebound therapy to physical condition were presented in the questionnaire. These were collated from Rollings (2005) and Lawrence (2004) as:

- stimulation of the cough reflex
- change in muscle tone (increased or decreased as required by child)

- development of saving / protective reactions
- increased proprioception
- improved coordination
- improved cardiovascular fitness
- improved head control
- improved posture
- increased bone strength
- improved balance

A change in muscle tone was reported to be the most significant benefit of rebound therapy are – 70% of participants agreed. Improvements in balance (55%), posture (40%), proprioception (35%) and head control (35%) were also commonly stated as significant, whilst stimulation of the cough reflex (5%) and an improvement in bone strength (0%) were least commonly viewed as significant (please see figure 3).

When participants were asked why rebound therapy caused the stated benefits, most participants knew why all the benefits were caused except for increased bone strength: only 40% of participants knew why rebound therapy may increase bone strength (please see figure 4).

Figure 4 shows that 80% of participants understood why balance was improved during rebound therapy; 75% of participants understood why head control improved; 65% of participants knew why coordination improved; and 60% understood why muscle tone changed.

The questionnaire does not help answer how rebound therapy improves muscle tone, but it does show that rebound therapy's effect on muscle tone is the most significant benefit. This heightens further support for the Dissertation's rationale.

FIGURE 3: Practitioners' Opinions of the Most Significant Benefits Attributed to Rebound Therapy

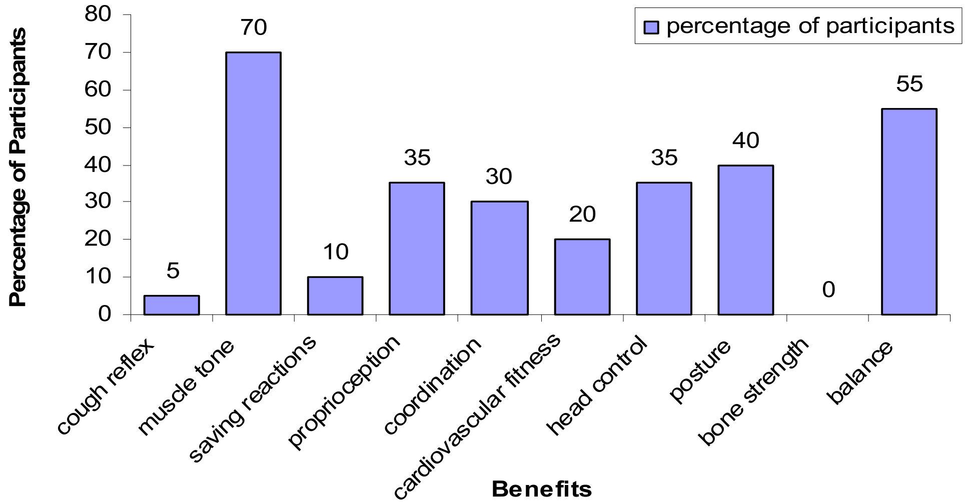
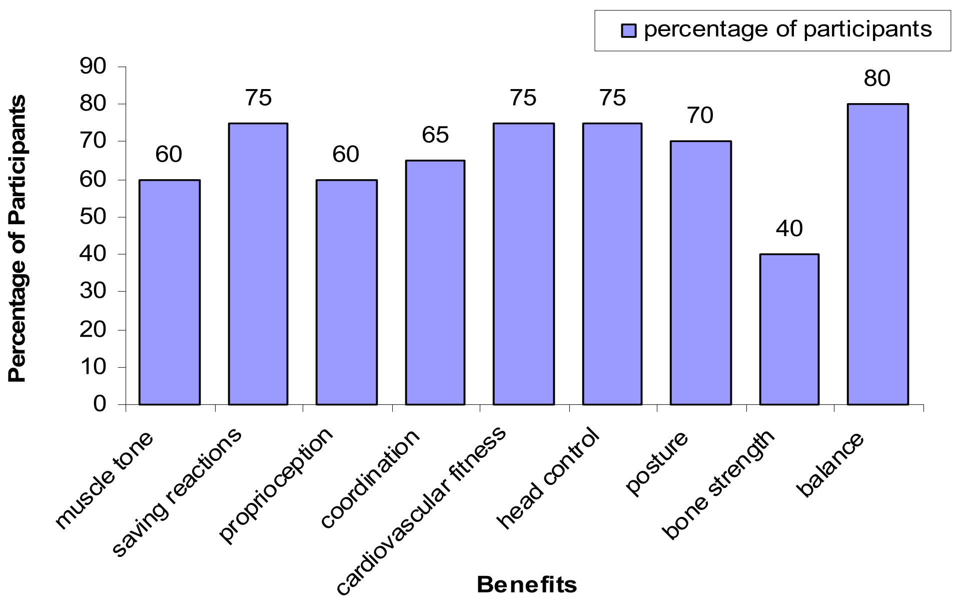


FIGURE 4: Percentage of Participants who Understand why Rebound Therapy Causes the Stated Benefits



5: DISCUSSION

Triangulation of the three methodologies implemented in the research have, combined, highlight rebound therapy's effect on muscle tone. The results of the questionnaire show that practitioners undoubtedly agree that rebound therapy benefits children with profound and multiple learning disabilities and furthermore, that muscle tone is the most valuable benefit rebound therapy causes. An interview with a rebound therapy expert also supported these claims, and support for Rollings' (2005) claims which has provided a firm and reliable foundation in proposing how rebound therapy improves muscle tone. This was collated with data obtained from observation of rebound therapy sessions and applied to the reviewed muscle physiology resulting in a specific explanation for Rollings' claims.

The need to explain these proposals in greater detail in terms of underlying physiology, is concurrent with Mayston's (2000) claims that therapies need to be investigated. Without a clear understanding of how rebound therapy improves muscle tone, the exercises undertaken to theoretically improve muscle tone, may be done incorrectly, which will detract from and infringe on the benefits.

5.1 THE VALUE OF REBOUND THERAPY

Rebound therapy may benefit children with physical disabilities for many of the same hypothesized reasons as therapeutic horseback riding and hydrotherapy: it combines weightlessness and rhythmic, three-dimensional movements.

It was hypothesized that THR is effective in challenging balance and improving postural tone because of the rhythmic, three-dimensional movement, the constantly changing relationship between the child's centre of mass and their base of support, and the instability of the surface demanding righting reflexes. Rebound therapy replicates this: it challenges balance by inducing a rhythmic, three-dimensional movement by the therapist pushing the bed from underneath the child; it has an unstable surface (Hartley and Rushton, 1984); and the trampoline's movement constantly changes the relationship between the child's centre of mass and their base of support. As balance is dependent on the integrity of muscle tone, rebound therapy may improve muscle tone by providing constant opportunity of postural muscles to adapt to the shifts between the centre of mass and base of support.

Furthermore, opportunity for sensory integration of kinesthetic, visual, and vestibular input necessary for developing motor control provided by THR – and credited for its benefits – is heightened in rebound therapy (Rollings, 2005; Noda *et al.*, 2003). The vestibular system relies on neural pathways so for children with neurological impairments, the vestibular system may therefore be affected which in turn, affects visual and motor responses which maintain balance. Therefore by heightening the vestibular sensory system – which in itself is a benefit – muscle tone may be indirectly improved as muscles gain practice in responding to CNS impulses in an attempt to maintain balance. Similarly to THR being 'controlled' by the horse, in rebound therapy the bouncing is controlled by the therapist so much like the variations in horse's stride, velocity and direction stimulating righting and equilibrium responses, the shifts in the trampoline bed also demands a response: the instability of the bed immediately throws the child's body off midline and the brain and CNS is forced into re-organising the self.

5.2 Mechanisms to Increase Low Muscle Tone

When a child with low muscle tone lies on the trampoline, the bed's elastic fibres stretch to accommodate the child's weight and shape. Automatically, the sensors in the skin are stimulated by the feeling of the trampoline's texture.

The stimulatory pressure to the skin has been postulated to increase hypotonia: Rollings (2005) claims that tone is increased because of the stimulatory effect upon the sensory systems; a claim which has been supported by the interviewee in this research. The interviewee further explained that low muscle tone was increased because the vibrating bed stimulates the muscles, forcing them to react against the surface and it is this 'forced reaction' which causes muscles to increase tone (Appendix 3).

The repetitive changes in pressure to the skin resulting from repetitive bouncing, stimulates muscle spindles. This 'tapping' effect vibrates the muscle spindles which tighten in response to the increased sensory stimulation. This heightens awareness in the brain and CNS resulting in more impulses to be innervated resulting in an increase in tone.

When the muscle is stretched, as is caused by bouncing, it stretches the spindle, exciting its sensory nerve endings. The spindle relays information to the nervous system about the rate of the stretch which is conveyed to the muscles via the stretch reflex: the continuingly increased sensory stimulation causes activation of the stretch reflex resulting in contraction. This contraction increases tone: stimulated by the continuation of persistent bouncing, a greater number of muscle action potentials are fired. This results in the increased activation of myosin cross bridges, and subsequent myofibril contraction.

The effect of being in contact with a vibrating bed is further accentuated by exercising in different positions (e.g. see appendix 9) thus activating and increasing tone of different muscle groups: the trampoline's stimulatory effect affects the muscles to varying degrees. For example, during high kneeling, thigh muscles will become tenser to support the bent knees; hip flexors will increase in activity; axial and scapular muscles will increase in activity to support the arms being outstretched; and activity in the trapezius and sternocleidomastoid will increase as the child tries to lift their head. Coupled with the vibratory effect, the increase in tone is theoretically – and hypothesised here to be – accentuated.

In hypotonic muscles, the muscle spindle is slack and not sensitive to changes in muscle length. Stimulation of muscle spindles causes muscle fibers to contract so as a bouncing rhythm is established, the spindles become tauter as they are repeatedly shaken and stimulated. By becoming tauter, they become more sensitive to changes in the muscle length, therefore improving tone.

5.3 Mechanisms to Decrease High Tone

Rollings (2005) proposes that high muscle tone is reduced in rebound therapy because of the vibratory effect on the muscle spindles. Vibration of spindles induces their relaxation which decreases the innervation rate of muscle action potentials: muscles lengthen thus reducing tone. By effect of exercise, tone is further reduced as muscles warm up and increase in elasticity.

Unlike bouncing causing an increase in tone in hypotonus muscles, the bouncing causes a decrease in tone in hypertonus muscles. It is imperative to reiterate that hypertonia results from excessive activation of myosin cross bridges causing tautness. In hypotonia, it is the stimulation of muscle spindles which causes an increase in tone – incessant stimulation pressurizes and compels slack spindles to contract the muscle. In hypertonia, muscle spindles are taut: gentle shaking results in their relaxation – instead of stretching causing muscular contraction, stretching causes muscle lengthening. Also, the degree of bounce contributes to tone improvements: too much bounce increases spasticity and too little results in under stimulation (Rollings, 2005). Gentle bouncing can stimulate skin receptors to release endorphins which induce relaxation and calm (Lacroix *et al*., 2004).

As a bouncing rhythm is established, the body moves in a vertical motion. As the body hits the bed, it slows down and at one point stops (Rollings, 2005). At this point, the compressive forces within the body are highest. Once the trampoline bed has reached its lowest point where its fibres are most stretched, its elasticity causes it to recoil resulting in upward thrust of the child (Horne, 1968). As the body leaves the bed, there is an accelerating effect as it gains speed. At the highest point that the child's body reaches, the compressive forces are at their lowest – there is less pressure exerted on any one point. The change in compressive forces affects muscles, joints and organs.

Although the body tends to move as a whole, due to the presence of intracellular and extracellular fluids, there is a tiny amount of give between the organs and the skeleton: the organs are neither rigid, nor rigidly attached. Imagine it if you will, as bouncing a large transparent ball with a tiny ball inside. The larger ball's bounce is limited by external factors but the inner ball's bounce is limited by the larger ball's perimeter as it bounces from top to bottom of the outer ball's wall. As a result the two balls do not move concurrently. By similar concept, the organs move slightly behind the body's frame which adds to the increased compressive force at the bottom of the movement, and decreased compressive forces at the height of the movement. This not only aids circulation, but can decrease tension within the whole body causing much needed relief for a wheel-chair bound child with limited movement capacity.

Due to the presence of synovial fluid, there is also a small amount of laxity surrounding joints which in the same way, allows increased freedom of joint movement. The same effect occurs within the muscles. At the lowest point of the vertical motion (the bounce), compressive forces on the body are greatest. This also means that there is the greatest amount of compressive force and pressure on the muscle fibres. This results in the greatest amount of tension and overlap between the myofilaments. At the peak of the vertical motion, there is the lowest amount of compressive force and consequently a decrease in the pressure exerted on the muscle. This allows the myofilaments to pull apart. As a pioneering theory to propose how rebound therapy improves muscle tone, the researcher suggests that the regular bouncing establishes a rhythm between the amount of overlap (and therefore the amount of contraction) between the myofilaments: at the lowest point of the vertical motion, the increased compressive force and pressure pushes the myofilaments together; at the peak of the vertical motion, decreased compressive force and decreased pressure allows the myofilaments to move apart (please see Figure 5). Therefore, at the lowest point of the bounce, there is the greatest amount of overlap between the actin and myosin thus greater contraction; and at the peak of the bounce, there is the least overlap between actin and myosin, thus less contraction. This motion and pattern is repeated throughout the rebound therapy session accentuating the amount of laxity within the muscles, and combined with the increased temperature as a result of exercise, high tone is gradually lowered and muscles lengthen.

FIGURE 5a: A Relaxed Sarcomere: Hypothesized to Demonstrate a Sarcomere in a Muscle at the Peak of Vertical Motion

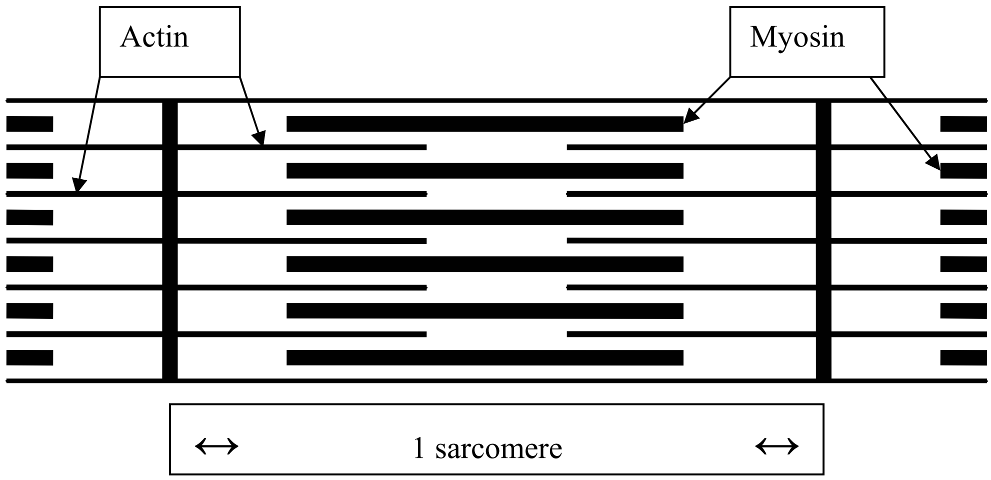
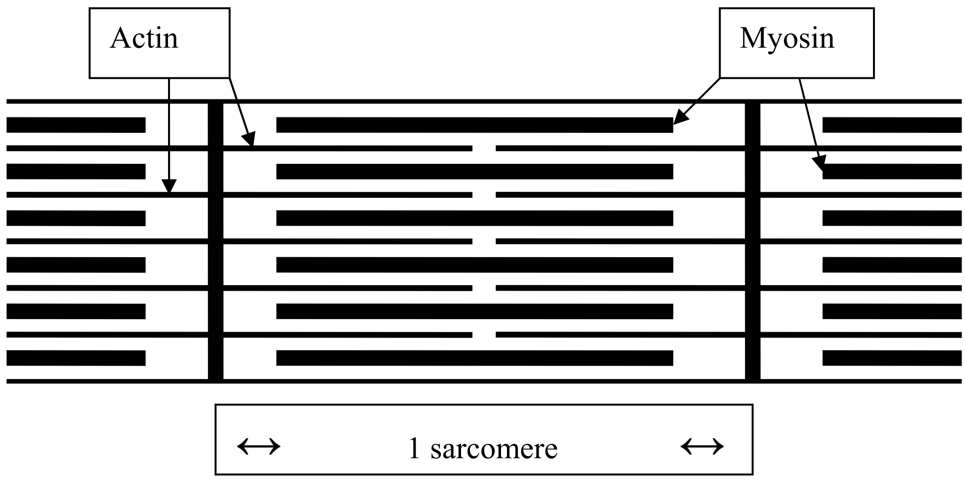


FIGURE 5b: A Contracted Sarcomere: Hypothesized to Demonstrate a Sarcomere in a Muscle at the Bottom of Vertical Motion



5.4 Co-contraction and the Stretch Reflex: Case Study – BL

BL has some increased tone on her right side (Table 1). During observation of rebound therapy sessions, BL laughed as her wrist was hyper-extended to put her hand flat on the bed. The therapist attributed this to the stretch reflex rather than enjoyment and explained that uncontrollable laughter is common in neurologically impaired children when they are in pain.

Muscle spindles in BL's wrist extensors were activated as passive stretching was initiated. However, due to impaired neural pathways, the stretching caused co-contraction between the wrist extensors and wrist flexors, causing pain as each muscle group fought against the other.

The therapists continued to bounce and did not release the hand from that position. With knowledge of co-contraction, one can see why suddenly stopping the bouncing movement would be detrimental. The level of stretch reflex is modified throughout movement: in the first phase, the stretch reflex is rapidly heightened to cause immediate contraction but as the stretch continues, the spindle slackens and becomes less sensitive to muscle length changes. By stopping the bounce immediately the pain would continue because the muscles are extremely tight. By continuing to bounce and further stretch the muscle, not only is the spindle becoming less sensitive, but shaking of it is decreasing tone. Continuing to 'bounce through the pain' lengthens and softens the muscle, thus reducing the tone and removing the source of the pain.

5.5 Newton's Laws of Motion

The results of this research highlight several explanations as to why rebound therapy is more effective compared to when doing the same exercise on the floor (Appendix 3).

Results from the interview highlight several attributions as to why rebound therapy benefits children with PMLD. These include the effect of compressive forces, kinesthetic feedback, gravity, increased vestibular feedback and Newton's Laws of Motion. One can not have failed to identify the value of compressive forces, however the application of Newton's Laws are also useful in explaining why rebound therapy improves muscle tone.

Newton's first two laws state that a mass will remain at rest or at constant linear speed until other forces are impressed on it; and the impressed forces alter the direction of the mass equal to the resultant product of the forces (Horne, 1968). In rebound therapy, the therapist must direct muscular energy to depress the bed, the bed recoils and thrusts the child into the air; and the adult's force and child's mass affects the height of the bounce. However, perhaps more crucial in explaining why the trampoline is beneficial and why rebound therapy is more effective than compared to the same exercise on the floor, Newton's third law states that for every action there is an equal and opposite reaction.

When children exercise on the floor, as an equal and opposite reaction, their weight is automatically equalled by the floor and the child bears their full weight. On the trampoline, however, some of the child's weight is displaced as it is absorbed by the bed: it is not difficult to see that jumping on a floor puts more stress on the joints than jumping on a trampoline. The trampoline responds pertinently to the child's weight and displaces some of it through stretching of the fibres in close proximity to the child (making a valley-shaped indentation): on a solid floor, only the area of floor in direct contact with the body takes the weight, thus counter-exerting all of it. This is particularly evident during a four point kneel position. In this position on the floor, a lot of weight is exerted through the arms which is counter-exerted, and intercepted by the elbows. Similarly, weight is intercepted in knees, which is why it is uncomfortable for anyone to kneel on the floor for long periods. However, on the trampoline, some of this weight is displaced and absorbed by the trampoline bed, thus lessening pain.

An understanding of Newton's Third Law also helps explain why high muscle tone is reduced in a shorter amount of time on the trampoline. Compared to doing the same exercise on the floor, the decreased pressure exerted on the muscles makes it easier for muscle fibres to relax. During a four point kneel, the arms are outstretched and taking some of the child's weight. The fibres are highly contracted; there is huge overlap between the myofilaments. The myofilaments run vertically within the muscle and therefore have the extra pressure of gravity and the child's weight counter-balancing their attempts to elongate. On the floor, the child's weight is counter-exerted; on the trampoline, however, some of the weight is absorbed in the bed's fibres, some of the weight is displaced in the fibres around the hands and during the upward phase of the bounce, all weight *and* the effects of gravity are removed. Coupled with the therapeutic bouncing shaking the spindles, myofibril elongation occurs even quicker.

5.6 USE OF EQUIPMENT

In rebound therapy, selective use of equipment also helps accentuate the benefits. Rather ingeniously, sitting astride a cylinder roll has several purposes. By fixing a child at the hips or knees while sitting in this position, it allows the child to only focus on their upper torso e.g. trunk stability, arm movements and head control. It also provides opportunity to gain awareness in both sides of their body because they are positioned symmetrically and helps challenge balance and postural mechanisms as it would be relatively easy to fall off without the therapist's support.

Furthermore, it has been concluded that sitting in this position – hip flexion and abduction – reduces EMG activity, and therefore hypertonia, in the hip adductors, knee extensors, plantar flexors and back extensors (Quint and Toomey, 1998). Furthermore, this sitting position combined with a rhythmic, three-dimensional movement in THR significantly improved pelvic range of movement when compared to sitting statically in the position (Quint and Toomey, 1998): rebound therapy can combine a rhythmic, three-dimensional movement and the astride sitting position thus reducing hypertonia in the stated muscles and improve pelvic range of movement.

5.7 STRENGTHS AND WEAKNESSES OF THE RESEARCH

It is of paramount importance to note that there is very little research into rebound therapy, and hopefully, this is very much a preliminary study.

5.7 *i* STRENGTHS

In addition to the research successfully fulfilling its aims, several other strengths should be highlighted. Firstly, improved muscle tone is requisite to other physical-condition improvements such as head control, balance and posture, and the mechanisms for improving muscle tone have been clearly stated here. As part of a severely under-researched area, which is in desperate need of clinical and scientific explanations for its effectiveness, this study has set a firm foundation for the instigation of further research. Furthermore, by reiterating the relevant muscle physiology and combining this information with data obtained from a rebound therapy expert, the researcher has developed a pioneering theory to explain how hypertonia is reduced.

5.7 *ii* WEAKNESSES

There are several limitations and weaknesses of the research but none are seen to affect the overall conclusion which explains how rebound therapy improves muscle tone.

Firstly the research should also be criticised for its large over-generalisation of neurologically impaired children. Because this research is the first of its kind, it was decided not to specialise in any one disability thus allowing the results to be more relevant to a larger population.

Secondly, a very small sample of children and a very small number of sessions were observed. This was clearly a limitation because it is difficult to make generalisations from small samples. However, a large sample is not highly important as the actualities of rebound therapy, in this case highlighted by the sessions observed, merely acts as a practical basis on which the scientific underlying muscle-physiology principles and data collected from the expert practitioner can be interpreted. Furthermore, the research could be criticised for simply observing one school's approach to rebound therapy, but it should be highlighted that the staff member who was observed most often, has twenty-four years of experience.

The questionnaires were also not without criticism. Due to the lack of time staff have within school, it was not appropriate to sit down with each participant as they completed the questionnaire, despite this being 'best practice'. It was therefore difficult for staff to ask for help which may have resulted in misinterpretation and inaccurate responses.

However, a bigger criticism occurs when participants were asked if they knew why rebound therapy caused the stated benefits: staff could be economical with the truth about how much they knew or be incorrect in their understanding, also thus producing inaccurate responses. It was deemed inappropriate to ask staff to write down why rebound therapy caused the stated benefits as it would be too time consuming.

5.7 *iii* Fulfillment of Aims and Objectives

The primary aim of the research was to explain the precise physiology of Rollings' (2005) claims of how rebound therapy improves muscle tone. The reiteration of relevant skeletal muscle physiology has enabled the researcher to fully explain the mechanisms of Rollings' claims and present an additional hypothesis.

A further aim of the research was to obtain the opinions of rebound therapy practitioners, and in doing so has heightened support for the Dissertation's rationale: 70% of practitioners believe an improvement in muscle tone is the most significant benefit rebound therapy can cause.

The research also aimed to apply the theory of how rebound therapy improves muscle tone to practical situations. By observing children with abnormal muscle tone, the researcher has been able to apply the theory into practice which runs throughout the Discussion.

6: CONCLUSION

In neurologically impaired children, high muscle tone results from excessive contraction; low muscle tone results from insufficient contraction. Furthermore, the ability to change muscle tone as required in maintaining stability, is concurrently also often impaired. Muscle tone is essential to posture, head control, efficient movement and functional activities, and therefore a lack of 'good' and responsive tone is detrimental to physical condition.

Rebound therapy can increase abnormally low muscle tone by exerting a persisting stimulatory pressure to the skin and decrease abnormally high muscle tone by vibrating muscle spindles, increasingly elasticity, and accentuating the amount of laxity within the muscle fibres.

Improving muscle tone is of paramount importance for physically disabled children. By doing so, it not only improves balance, movement capacity and functional capabilities, but may contribute to an improved quality of life, especially for a child with cognitive delay: for a child who gains the ability to control his head, he can see more and become more aware of his environment, thus opening up a whole new world.

6.1 FURTHER RESEARCH

Due to the dearth of investigation into rebound therapy, there is an unlimited amount of suggestions for further research.

- A standardised test to specifically measure the effect of rebound therapy on muscle tone e.g. the modified Ashworth Scale
- The effect of rebound therapy on head control, proprioception, posture, fine motor skills, or balance

- The comparison of rebound therapy to floor-physiotherapy via functional tests e.g. the Gross Motor Function Measure
- A longitudinal study to monitor the effects of rebound therapy
- The extent to which neural pathways and abnormal muscle properties contribute to hypertonia, hypotonia and impaired stretch reflexes – it would be naïve to conclude that rebound therapy improves hypertonia, hypotonia and the stretch reflex when demonstrably, it is semi-reliant on the brain and central nervous system

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