Effect of Gravitational Stress and Exercises on Bone Demineralization & Renal Complication in Paraplegics & Quadriplegics

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Abstract

Background: Spinal cord injury (SCI) is a multisystem injury with life-threatening complications. Bone demineralization renal complications have serious consequences for the affected person. It is hypothesized that verticalisation along with early mobilization reduces skeletal renal complications. Methodology: 48 subjects (36 patients+12 controls) participated in this study. The patients were divided into groups A, B C and the controls were in Group D. Basal parameters (BP, PR, RR) were recorded and Urine samples were sent for analysis. Group A was treated with only limb exercises Group B was given limb exercises tilt table standing. Group C had chronic patients to visualize the longterm effect of physical rehabilitation body?s attempt at bone mineral homeostasis on urinary parameters. Results: Significant changes were noted in the values of urine calcium, inorganic phosphate, hydroxyproline serum enzyme alkaline phosphatase among groups A, B C when compare with D.

Index terms— spinal cord injury, gravitational stress, renal complication, bone demineralization, active/passive exercises, verticalisation.

trunk, legs, bladder, bowels and sexual organs. Any SCI occurring at the level of the 2nd thoracic vertebrae (T-2) or distally can result in paraplegia, with accompanying impairments of the trunk, legs and pelvic organs, with a decreasing severity of deficiencies the more distal incursion of the SCI 1 . Persons with SCI have a reduced health status, decreased quality of life and increased rates of mortality compared to able-bodied population. The most common medical complications observed in SCI are muscular atrophy, bone metabolism disorders, cardiovascular disease & autonomic dysregulation due to removal of neural drive to the impaired muscles resulting in subsequent reduced metabolic demand accompanied by rapid & chronic deconditioning 2 . Osteoporosis: a well-known complication of SCI, is characterized by low bone mass & deterioration of the skeletal microarchitecture 3 . The mechanism of bone loss in SCI is not completely understood; however, a significant amount of bone loss occurs during the first 4-6 months after injury and stabilizes between months 12 and 16. Bone demineralization reaches almost 50% by the end of the first year following SCI. However, bone mineral loss continues to a lesser degree in the pelvis and lower extremities over the next 10 years 4,5 .

The pathophysiology of SCI-induced osteoporosis is complex and differs from that observed after prolonged bed rest in patients without SCI and in those with other neurologic deficits 6 .SCI can cause immediate and, in some regions, permanent gravitational unloading, leading to disuse structural change. It triggers significant increase in osteoclastic activity peaking at 10 weeks following SCI at values 10 times the upper limit of normal 7 .Hypercalciuria is 2-4 times that of persons without SCI who undergo bed rest and reaches a peak 1-6 months post injury; this marked increase in urinary calcium is the direct result of an imbalance between bone formation and resorption 8,9 .A reduction of bone mineral content during the first year after the injury of 4% per month

in regions rich in cancellous bone, and 2% per month on sites containing mainly cortical bone is reported 10 . SCI-mediated hormonal changes also lead to osteoporosis by 5

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2 I. Introduction

spinal cord injury (SCI) is a multi-system damage with life-threatening complications. It can result in autonomic, neuromuscular and physiologic impairment of the legs, arms or trunk with the severity of the symptoms dependent upon the level and magnitude of the injury to the spinal column. A SCI to the cervical segments of the spinal column (C1-C8) down to the most proximal thoracic segment (T-1) often causes quadriplegia and results in impairment of the arms, A 11,12 . In the absence of adequate treatment, calculi can lead to sepsis & renal failure. The major risk factors found are 13 -? Hypercaliuria ? Increased susceptibility to Urinary tract infection. ? Immobilization ? Stasis of urine ? Altered urine ph

The chemical composition of SCI-related urinary stones is predominantly nonoxalate calcium (carbonate apatite) during the early years and consists of a higher proportion of magnesium (struvite) in the later years 14 .

It is hypothesized that verticalization, early mobilization & exercising of paralysed muscles may lower blood & urine concentration of catabolic products from collagen & bone and thus reduce the skeletal & renal complications 15 . Donaldson et al found that quiet standing for 2 hrs a day appears to reverse the changes in mineral metabolism induced by immobilization, whereas vigorous supine exercises for as long as 4 hrs daily is ineffective 16 .

Therefore, this study was undertaken to compare the effects of tilt-table standing & limb exercises against limb exercises alone in paraplegics & quadriplegics with a treatment regimen of 15 days. Also a comparison was made to assess the levels of urinary parameters between chronic patients& normal ambulatory control group.

3 II. Methodology

Post an institutional ethics committee approval, an informed consent was obtained from all the subjects prior to commencement of the study.

A total of 36 patients with a spinal cord injury, level of lesion ranging from C3-4 to T12 vertebrae were included in this study. Their age groups ranged between 18-55 yrs. The cause of lesion varied from trauma, myelopathy, transverse myelitis, and extra medullary tumor to Koch's spine. Participants were recruited from the outpatient & inpatient department of a tertiary care public hospital & a renowned paraplegic foundation for the study conducted for a period of 15 days. The inclusion criteria were as follows- Inference: Levels of phosphate showed significant difference in group B while it was non-significant in group A.

4 IV. Discussion

The recent progress in the management of SCI has prolonged the survival of patients. The incidence of secondary bone & joint disorders has also increased considerably 17 . Bearing in mind the evaluation and particularities of the osteoporosis occurring in SCI patients, one should pay special attention to the time of injury. Intervention must ideally be introduced early as a large portion of bone loss occurs within 6 months, stabilizing at 12 to 24 months after SCI at values 60% to 70% of normal in the femoral neck and 40% to 50% in the proximal tibia 10,18 . The physiological changes in various systems occur as a result of 19 20 . A study demonstrated that standing might reduce the loss of trabecular bone after SCI. In this prospective study of 19 acute SC? patients, the patients involved in early loading intervention exercise lost almost no bone mineral, whereas the immobilization patients lost 6.9 to 9.4% of trabecular bone 21 .

5 Volume

A study done by Schoutens et al. has shown that exercises without weight bearing cannot counter act the loss of bone mass provoked by bed rest. Also, Kaplan et al, observed reduction in hypercalcemia in quadriplegics after weight bearing & strengthening exercises. Our findings, depicted in tables 1, 2, 3 & 4 correlate well the above studies. Mild significant fall in urine calcium is observed in group A too due to the fact that muscle loading & contraction in the form of active & active assisted exercises, promote maturation of newly formed collagen & calcification of bone matrix 8,21 .

Hydroxy proline also, returned to baseline as found in our study, supported by conclusion by Bergmann et al & Chantraine A 22,23 .

The abnormality in bone mineral metabolism is directly proportional to the amount of bone tissue immobilized. Thus, SCI patients develop hypercalciuria & mild hypercalcemia. With time, the bones become severely osteoporotic, mobilization of calcium reduces & eventually normalizes 15 . This was confirmed by our study in table 5. Since the patients in group C had a mean duration of paralysis of 16 yrs, the urinary levels had come back to their normal limits. This could be because of the body's adaptive strategy to control bone mineral loss over a prolonged period. During this period changes in hormonal factors such as growth hormone or a decrease in IGF-1 may result in a reduced bone turn over 24 . Also, the independent & active lifestyle that the patients were leading played a crucial role.

6 a) Limitations

? Male to female ratio could not be maintained equally ? The level of lesion varied amongst patients recruited ? Cause of the lesion was different in amid patients ? Duration of paralysis was also different between patients ? The study had to be restricted to 15 days because of early discharge of patients.

7 V. Conclusion

Thus in our study we conclude that- [1] [2]

Figure 1:

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URINE HYDROXY PROLINE		
DAYS	GROUP A	GROUP B
1	2.93 + 0.43	2.98 + 0.78
7	2.83 + 0.29	2.64 + 0.48
15	2.78 + 0.29	2.29 + 0.48
t value	2.45	4.54
p value	< 0.05	< 0.001
Inference: Levels of hydroxy proline showed significant difference in group B		

Figure 2: Table 3 :

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of serum enzyme alkaline phosphatase between group A & B

SERUM ENZYME ALKALINE PHOSPHATASE		
DAYS	GROUP A	GROUP B
1	12.39 + 2.09	14.13 + 2.98
7	11.60 + 1.17	11.25 + 1.74
15	11.14 + 1.23	10.01 + 2.41
t value	2.91	7.1
p value	< 0.05	< 0.001

Inference: Serum enzyme alkaline phosphatase was significantly reduced in group B after 15 days of treatment

Figure 3: Table 4 :

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of urine parameters between group C & D

URINARY PARAMETERS		
PARAMETER	GROUP C	GROUP D
CALCIUM	6.79 + 1.39	6.91 + 0.95
PHOSPHATASE	65.65 + 6.61	64.02 + 5.84
HYDROXY PROLINE	2.55 + 0.48	2.19 + 0.49
SR. A. P	12.03 + 2.89	11.60 + 1.09

Inference: Urine parameters & serum enzyme alkaline phosphatase were near normal between groups C & D

Figure 4: Table 5 :

? Change from partially upright-partially horizontal body position to a completely horizontal one
? Reduction in energy expenditure due to relative confinement in bed
? Almost complete reduction of stress on muscles & bones
Muscular loading of bones has been thought to play a role in the maintenance of bone density. Exercise increases site-specific osteogenesis in able-bodied individuals

Figure 5:

Figure 6: ?

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