Bratisl Lek Listy 2011; 112 (1)
41–43

REVIEW

The importance of carrying a backpack in the rehabilitation of osteoporotic patients (biomechanical analysis)

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Abstract: Based on a simple biomechanical analysis available to physicians, the article recommends carrying a backpack regularly as a part of the complex rehabilitation of osteoporotic patients. Carrying a backpack in front or on the back is recommended to patients with uncomplicated osteoporosis, while carrying a backpack on the back only is recommended to patients with osteporotic vertebral fractures. The importance of carrying a backpack is based upon removing the muscular dysbalance of the trunk muscles and upon increasing the bone strength by compressive force acting upon the vertebrae and proximal femur and activating osteoblasts to enhance the process of osteoformation. The backpack load is differentiated – patients with vertebral fractures put a weight up to 1 kg into their backpacks, patients without vertebral fractures increase the load up to 2 kg *(Fig. 2, Ref. 12)*. Full Text in free PDF *www.bmj.sk.*
Key words: osteoporosis, vertebral fracture, biomechanics, rehabilitation, backpack, muscular dysbalance.

The aim of this short statement based on a simple biomechanical analysis available to physicians is to explain the benefits of carrying a backpack in rehabilitation of osteoporotic patients.

Carrying a backpack alternately *in front and on the back* is recommended to:

- Patients with vertebral osteopenia and osteoporosis (without vertebral fractures) and muscular dysbalance of the trunk muscles (Fig. 1).

Effect: removing the muscular dysbalance of the trunk musculature, activating the osteoblasts to enhance the process of neoformation of bone by compressive forces acting upon vertebrae and increasing the bone strength (1–5);

- Patients with osteopenia and osteoporosis in the area of proximal femur.

Effect: stimulating the osteoblasts to enhance the process of osteoformation by compressive forces acting upon the area of proximal femur and increasing the bone strength (1–5).

Carrying a backpack on *the back only:*

- Recommended to patients with osteoporotic vertebral fractures (6)

Patients with osteoporotic vertebral fractures

Osteoporotic vertebral fractures represent the most frequent complication of osteoporosis and contribute to partial or full disabling of patients. Kyphosis, as a consequence of wedge-shaped

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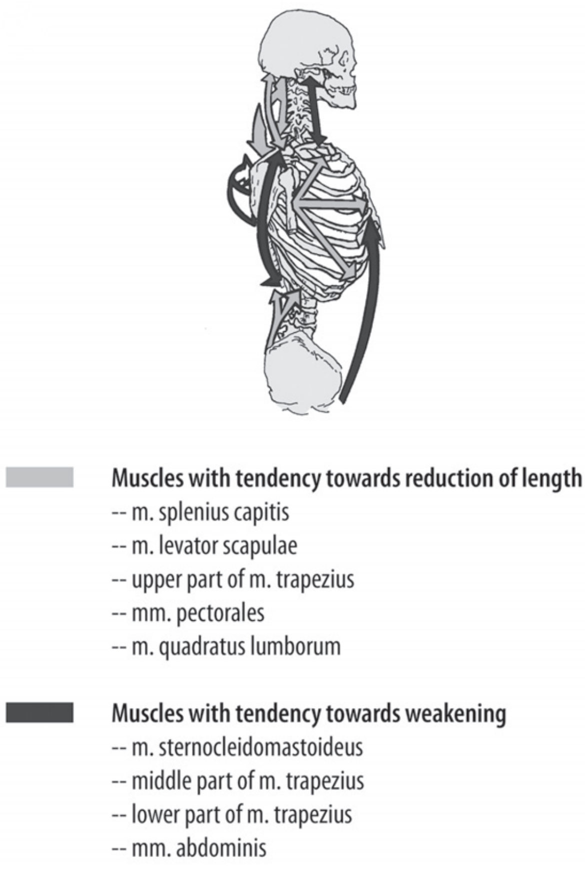

Fig. 1. Muscle groups of the neck and the torso, subject to muscular dysbalance.

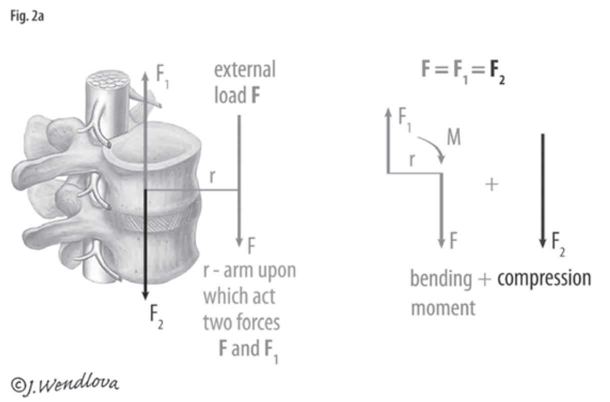

Fig. 2a. Biomechanical model of stressing the spine by external vertical load (force F).

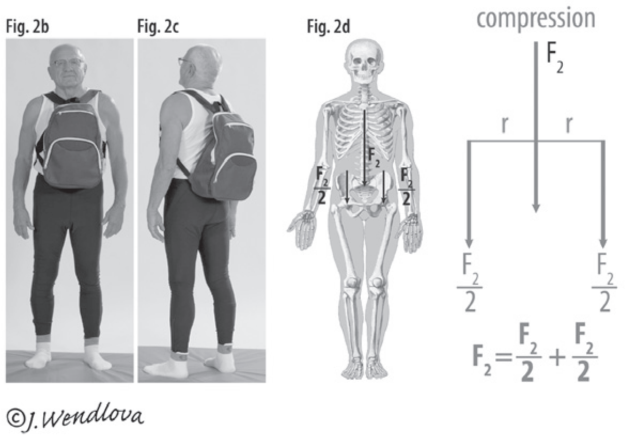

Fig. 2b, c, d. Stressing the spine and the hip joints by the compressive force (F2) and the distribution of the compressive force (F2) from the spine into the hip joints while carrying a backpack. (Figurant: Ass Prof. PhDr. Bohuš Hatiar, CSc.)

deformation of fractured osteoporotic vertebrae in the thoracic or lumbosacral area, conditions the biomechanical changes in the organism with a consequent grave clinical symptomatology:

- Deviation of body's gravity centre from its normal position,
- Muscular dysbalance of trunk musculature,
- Ileocostal friction syndrome (the rib arches rub the ala ossis ilii when walking and when in motion),
- Pathological position of disci intervertebrales in kyphosis and their non-physiological load (decrease in compressive forces upon ventral part and decrease in tension forces upon dorsal part of intervertebral discs),
- Growth of compressive forces upon pulmonary parenchyma,
- Development of cor pulmonale chronicum,
- Ischemia or venostasis in intraabdominal organs, non-specific intermittent abdominal pain, chronic constipation,
- Chronic backache (6).

Patients with osteoporotic fractures are recommended to carry a backpack on their backs. The following positive effects can be achieved:

- Careful stretching of shortened pectoral muscles,
- Strengthening the stretched and weakened dorsal muscles (balancing the muscular dysbalance),
- Potentiating a moderate straightening of the spine and mild the ileocostal friction syndrome and reducing the tension forces acting upon dorsal muscles,
- Reducing the compressive forces acting upon organs of abdominal cavity,
- Displacing the deflected gravity centre closer to its physiological position – improving the patient's stability,
- Reducing the compressive forces acting upon the ventral part of intervertebral disc as well as the tension forces acting upon the dorsal part of intervertebral discs in the site of pathological kyphosis,
- Rise of the maximal breathing capacity,
- Restriction of pain intensity in the back (6).

Biomechanical analysis (7–9)

The importance of carrying a backpack can be explained by a simple biomechanical model, represented in figures 2a–2d. The force F situated in front of vertebrae simulates the external load (e.g. a backpack, worn in front). To determine the way of how the force F is transferred into the vertebrae, the model example is solved by situating a couple of forces in the axis of vertebrae. The couple of forces are two forces of the same magnitude acting in the same ray and in the same point of application, however in opposite direction and sense while it holds true that:

$F=F_1=F_2$

The equilibrium status of forces does not change as the effects of both added forces are mutually cancelled. This couple is also called the couple of zero forces.

Forces F_1 and F_2 produce a positive bending moment M on the arm r (acting clockwise) and the force F_2 is transferred as compressive force into lower situated vertebrae and through both hip joints into both lower limbs.

Solution result: *External load by the force F is transferred to the vertebrae as a bending moment M and compressive force* F_2.

Carrying the backpack regularly (about an hour daily) and alternating its position from front to the back balances the muscular dysbalance of the torso musculature. Simultaneously, the compressive force in the vertebrae and in the proximal femur area is increased. The compressive force stimulates osteoblasts to produce the bone tissue (activation of oesteoformation), and thus increase the bone strength.

Load amount

Since we cannot calculate a load that would be safe for an individual patient and we do not know the ultimate strength limit for osteoporotic and fractured vertebrae in vivo, we can recommend only a very low load.

The patients with vertebral fractures put a load of up to 1 kg into their backpacks, the patients without vertebrae fractures increase their load up to 2 kg (10).

Carrying a backpack in front

The backpack represents an external load stressing the spine to bend and press. The body defends itself against the bending moment of the backpack's gravity force *(M)* pulling the trunk to bend forward, mainly by an isometric contraction of abdominal muscles and less intensively by contraction of dorsal muscles. These muscles are strengthened and should the pelvis be in horizontal line, the compressive force (F_2) is symmetrically distributed from the spine through hip joints into both lower limbs. At the same time, carrying a backpack in front makes the shortened pectoral muscles stretch (6, 11).

Carrying a backpack on the back

The body defends itself against the bending moment of the backpack's gravity force

(M) pulling the trunk to bend backwards. This situation mainly brings about an isometric contraction of the dorsal muscles and less intensive contraction of abdominal muscles. In doing so, the muscles become stronger. The backpack's gravity force also carefully stretches the shortened pectoral muscles and the compressive force (F_2) is also symmetrically distributed from the spine through the hip joints into both lower limbs (6, 11). The force *F* (external load) will be situated in the back of the spine and the bending moment *M* will be negative (acting counterclockwise).

Conclusion

For patients with uncomplicated osteoporosis as well as for those with osteoporotic vertebral fractures, regular carrying of a backpack represents an easily accessible and effective daily low-cost rehabilitation, which is part of their complex kinesitherapy. It allows the patient to carry a backpack while doing small shopping, walking in a park or on other easy terrain.

It is necessary to be aware that during the combination of carrying a backpack and Nordic walking, a certain magnitude of compressive forces is transferred from the patient into the poles and the rehabilitation effect of carrying a backpack is thus diminished (12).

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Received February 6, 2009.
Accepted October 8, 2010.