Use of the Torqway device in rehabilitation and for health-related purposes.

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1. Introduction

Torqway, a manually driven vehicle enabling transportation in an upright position, was created primarily for sports and recreation (Image 1, 2, 3). Due to the beneficial effects on the motion organ and on the cardiovascular system it may also be used in rehabilitation.

Image1: Torqway (www.torqway.pl)

The basic version of the vehicle is driven by the muscular activity of the user. Regular activity on Torqway can have a beneficial effect on muscle strength and endurance, on coordination, body balance, respiratory system, circulatory system, cooperation between the hemispheres of the brain, and the mental state of the user. Activity on Torqway combines elements of Nordic Walking and working out on the Orbitrek -type device. The device can be used to drive around the city, in the park, on a bike lane, or in the shopping mall. It enables speeds of up to 12 km / h. The device contains a 1-speed gearbox; therefore the value of multiplying ratio between the rotation of the lever and the rotation of the wheel is constant. There is also a model of Torqway with a seat. In view of certain ease of operation of the device, it can be used by children, adults and elderly people alike.

2. The biomechanics of the body while riding Torqway

In order to determine the application of the device in rehabilitation it is worth analysing which parts of the body are activated and how during the Torqway ride. The vehicle is driven primarily by intensive work of muscles of the upper limbs and torso. Manually operated levers, both during their forward and backward motion, generate unidirectional rotational movement of the wheel axis, causing the forward movement of the vehicle. Riding in reverse is not possible. The vehicle brakes through movement of the lever from the person's sagittal plane.

During propulsion of the vehicle, primarily the motion in the shoulder and elbow joints occurs. In a direct way work mainly muscle flexors of the shoulder joint (biceps, coracobrachialis muscle, the front deltoid muscle, greater pectoral muscle), rectifiers of the shoulder joint (arm triceps, latissimus dorsi muscle, the rear part of deltoid muscle), the elbow joint flexors (biceps, brachioradialis), rectifiers of the elbow joint (arm triceps) and the muscles responsible for the hand grip [1]. The study also showed high activity of the pectoralis major muscle [2]. The work of muscles is primarily based on concentric contraction. In addition, muscles within the shoulder blades and torso, including the abdominal muscles, are incorporated into operation.

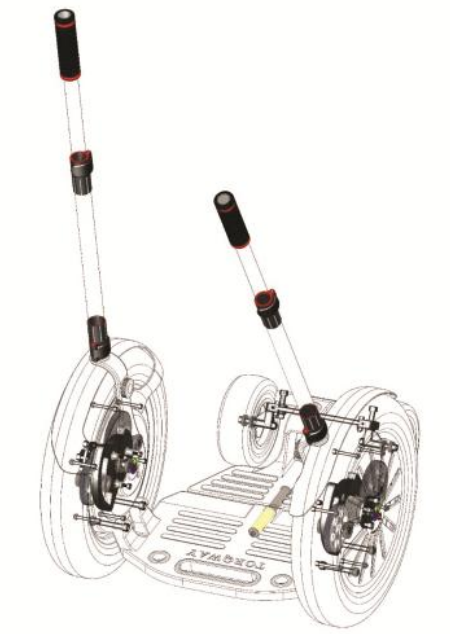

Image 2: Torqway (www.torqway.pl)

Muscle activity is also transferred to the lower limbs. The muscles of the lower limbs (except for muscles within feet and ankles) work primarily through isometric contraction, since there is no major movement in the hips and knees. The direction of travel is essentially controlled by the activity of the feet. In order to make a turn to the right, pressing the pedal with a right heel is necessary. During turning, the difference in rotational speed of driven wheels is also significant. For braking, an outward arms motion is used, namely activity of abductor muscles of the shoulder joint (supraspinatus, the shoulder's deltoid muscle) and the muscles externally rotating the shoulder joint (supraspinatus, teres minor muscle, the rear part of deltoid muscle) [1]. The length and frequency of the lever's movement is elective and depends on the user’s volition.

3. Physiological and biochemical responses during exercise on Torqway

According to the physiological and biochemical studies performed by employees of the Academy of Physical Education in Krakow it was found that activity on Torqway provides greater physical exertion than walking at the same speed.

Intensified oxygen consumption, ventilation of the lungs and heart rate was found. When riding on Torqway maximal oxygen uptake was higher by 5% and a maximal heart rate by 18% -compared to marching. During the march, subjects have burned 320 kcal / h -compared to 384 kcal / h when using Torqway. Thus, energy expenditure was 20% higher on Torqway than during march. Furthermore, when riding on Torqway, a greater increase in the concentration of lactate and hydrogen ions in the blood without disturbing the acid-base balance was confirmed. On the basis of laboratory measurements and subjective assessment of the respondents, the effort on Torqway while riding at a speed of 4.8 km/h was defined as moderate[3].

4. The use of Torqway in patients with orthopaedic diseases

Torqway can be used in some patients with disorders of orthopaedic, neurological, cardiac or pulmonary type, for rehabilitation, recreation, and to enable accelerated mobility.

Among patients with orthopaedic diseases, Torqway can benefit people suffering from a cervical spine, thoracic or lumbar pain. Patients are recommended regular, moderate physical activity, without overburdening the spine. Cycling is in these patients often not advisable due to the unfavourable sitting position. Dynamic march or Nordic Walking can aggravate pain complaints. Therefore, the possibilities of outdoor physical activity for these patients are limited. While riding Torqway, however, those patients can practice beneficial activity of the upper limbs in relation to a stable torso, thus strengthening the arm and abdominal muscles and safely activating the deep paraspinal muscles. If standing position is well tolerated, riding should not be painful for them. Torqway can enable patients with spinal problems overcoming greater distances than on foot.

Another group are persons after operations within the shoulder area (e.g. fracture fusion, rotator cuff sewing, labrum joint repair, implant arthroplasty) and after surgery of the elbow joint (e.g. the fusion of fracture), who after several weeks from operation should begin more intensive rehabilitation program aimed at strengthening muscles. For those patients activity on Torqway can be an alternative to training in the rehabilitation hall.

Version of Torqway with a seat allows for a partial relief the hip, knee and ankle joints. Therefore, it can be used by people suffering from the osteoarthritis of the hip, knee or ankle. This applies particularly to patients experiencing pain during walking and do not tolerate long-standing position, and would like to engage in outdoor activity or to overcome greater distances in a safe manner.

Seat version of the device can also be used in patients shortly after surgery of the lower limbs, such as: fusion of fractures, ligament reconstruction, repair of articular cartilage, meniscus repair, articular labrum sewing, muscle stitching, tendon repair, implantation arthroplasty. In these patients frequently in the initial period after surgery full limb strain and movement to the full extent are contraindicated. During this time, diversifying their physical activity by riding the Torqway with a seat, will allow them to move around without the risk of straining the limb. And in the later period Torqway can serve them to perform isometric workout of stable standing position.

Another group of patients who may benefit from the use of Torqway are those after amputations, for example as a result of advanced diabetes, atherosclerosis or due to traffic accidents. According to data obtained from the National Health Fund, every year a lower limb amputation due to vascular disease is carried out in more than 11 000 people [4]. Repeatedly these patients do not have a well-fitting prosthesis enabling them to travel over long distances. Riding Torqway (with or without a seat, depending on their state of health) could provide them with a form of both transportation and recreation.

In today's society, postural defects in children and adolescents due to lack of physical activity is a growing concern. It is often difficult to encourage exercise in persons of a young age. Training on Torqway may be an attractive alternative for them, through which they will be able to maintain the tension of paraspinal muscles' corset.

5. The use of Torqway in patients with neurological diseases

For people with paresis of lower limbs after a spinal cord injury at the level of thoracic or lumbar spine, Torqway with a seat may prove to be a revolutionary alternative to a wheelchair. Nowadays, there is still little recreational and sports facilities adapted to the needs of disabled people with a dysfunction of the lower

limbs, and the only form of transportation along the pavement available for them is a wheelchair. Torqway may enable more efficient patients with spinal cord injury to exploit their potential and to set their body in a higher position than if they were while sitting in a wheelchair. This could be the prevention of contractures and decubitus ulcers which often occur as a result of prolonged exposure to wheelchair. In weaker patients with spinal cord injury, however, an additional protection of the lower limbs and torso should be considered, for example with stabilizing belts.

Because of paraparesis suffer also, among others, patients with polyneuropathy, people after injuries with the peripheral nerve damage, patients with cerebral palsy and people with multiple sclerosis. In said diseases, upper limbs often remain efficient. Opportunity to ride Torqway with a seat could have significant impact not only on the possibility of covering longer distances, but also on physical and mental state and well-being of patients with lower limb paresis.

Persons with stroke and traumatic brain injury suffer from paralysis of half of their bodies (hemiplegia), causing non ergonomic, unsightly mower gait based on unfavourable compensations. In many cases, their rehabilitation takes many years and even a lifetime. Thus, diversifying their forms of physiotherapy is still being researched. Torqway can be proposed for training purposes to more able patients in chronic condition who reached a sufficient level of functionality of the upper limb and stability of their body in an upright position. Regular riding on Torqway not only can improve their strength and endurance, but also coordination, balance, co-operation between the left and right hemispheres of the brain, and their mental state. For people, whose muscles responsible for the hand grip are too weak, it is possible to modify the lever on the side of the paralysis and install a small hand support. This will enable the training of the upper limb without fear of problems with upholding the lever.

6. The use of Torqway for cardiovascular and respiratory diseases

Regular, but moderate physical activity is advisable in patients suffering from diseases of the heart and circulatory system. Physical exercise stimulates the blood vessels to produce new networks and thus increasing the vascularity area. These individuals usually need to exercise for a lifetime, but without overloading themselves

excessively. In some cases of pulmonary diseases, regular breathing exercises and moderate physical effort (especially outdoors) are advised. Torqway may prove, for patients with cardiac and pulmonary diseases, to be an alternative offer to group activities, at the pool or in rehabilitation centres.

7. Use of Torqway for the benefit of the elderly

The target group can also constitute the older people who want to maintain physical fitness for as long as it is possible. The fall prevention is very important in case of those individuals, involving the training of balance and coordination, and regular moderate exercise to prevent heart and musculoskeletal system diseases. Furthermore, there is an increasing group of seniors who have been diagnosed with osteoporosis. The rehabilitation of these patients consists mainly of strengthening muscles through isometric contractions. Therefore Torqway can be not only suitable, but also very useful to those persons.

8. Prevention of civilization diseases

Big social issue of today are persons of middle age, leading a sedentary life, chose non-rational nutrition and avoid physical activity, whereby they suffer from spinal diseases, obesity, cardiovascular disorders, hypertension, and diabetes. Those people often lack the motivation to exercise. In such cases Torqway may prove to be an attractive device introducing an additional form of movement into their day. An hour's workout on Torqway burns 400 calories, comparable with rowing and running.

Image 3: Torqway (www.torqway.pl)

Postural problems in children and adolescents due to lack of physical activity are also becoming a growing problem. It is often difficult to encourage exercise in people at a young age. Training on Torqway could be an attractive alternative for them, through which they would maintain paraspinal muscles' corset's tension.

9. Economic activity of the disabled

Torqway with a seat as an alternative to a wheelchair may enable persons with lower limb dysfunction to move more freely. This may contribute to their faster return to employment, which requires covering long distances, e.g. on large areas, airports, production halls, shopping centres, or factories. The hybrid version of the vehicle in which the rear wheels have electric drive can allow mobility for people with higher levels of disability. Creating a possibility of using Torqway in establishments with large surfaces could increase the number of disabled people employed there.

10. Safety while riding Torqway

Thanks to the low set platform and additional rear small wheels, the Torqway vehicle seems to be stable and secure. Due to the speed of the vehicle, however, there is some danger of falling. Persons suffering from any disorders are therefore advised to ride with a helmet. However, before a decision is made to use the device in a person not fully physically functional, a physiotherapist should be consulted, which will determine the locomotive abilities of the patient. Riding the device can not constitute a threat to the patient's organism. Not all patients will be able to respond correctly when having to perform a defence step. The forces working on the movement organ while riding are not beneficial for everyone. Extreme caution should be exercised in patients with neurological diseases. Physiotherapist should therefore perform basic research and patient testing to rule out the risk of health deterioration from the use of Torqway.

11. Summary

After analysing the working of the human body while riding on Torqway and the possibilities of use of the device, one can draw a conclusion that regular activity using Torqway can have a positive impact on muscle strength and endurance, coordination, body balance, respiratory system, circulatory system, cooperation between the hemispheres of the brain, and mental state. It may therefore enrich the process of rehabilitation of patients, constitute a prevention of diseases of civilization, allow for easier mobility in people for whom it is difficult. Torqway can be an attractive

alternative to sports and outdoor recreation for people of all ages and levels of fitness.

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