Therapeutic horse riding is often employed for disabled children. The aim of the present paper was to determine the influence of exercise in a mechanical saddle, imitating horse's walk, on the skin temperature responses in lower limbs in children with cerebral palsy. Sixteen children, aged 14-16, were enrolled into the study. Skin surface temperature was assessed with thermography, using an infrared thermovision camera, AGEMA 550, before and directly after 20 ±5 min of exercise. The findings demonstrate that mechanical hippotherapy provides an exercise stimulus that is capable of inducing a visible change in skin temperature of paralyzed limbs. The change, however, is one of a decrease in skin temperature, which points to acute vasoconstrictive effects of exercise and to decreased skin blood flow. The results, therefore, do not support the use of mechanical hippotherapy in children suffering from cerebral palsy, with a hope to stimulate blood circulation to spastically altered limb muscles and thereby to improve physical disability, at least in a short-term exercise paradigm.

Key words: cerebral palsy, children, exercise, hippotherapy, rehabilitation, thermography

INTRODUCTION

The treatment of cerebral palsy relies on the assessment of the degree of the handicap and aims at reducing the physical disability to a possible minimum.
Aside from pharmacotherapy and other forms of treatment, physical rehabilitation is essential, particularly in children. Exercise should be patient friendly; otherwise it could have adverse psychological effects which could deepen pathological changes in muscle tension (1-3).

One way of rehabilitation is hippotherapy, which is a therapeutic horse riding often used in children with cerebral palsy (4). Hippotherapy is a multiprofile rehabilitation method that not only helps treat sickness of organ movement, by inhibiting sustained pathological reflexes and facilitating the physiological ones, or correcting muscle tension, but also enhances psychological health by increasing social integration of sick children (4, 5). The results of hippotherapy are, however, not clear-cut and the therapy seems only individually efficacious.

The motion pattern of a child sitting on a horse that moves in a relatively slow-paced way may be simulated by means of a mechanical saddle. That is a kind of exercise, which although devoid of the contact with a living animal, has the advantage of being possibly performed on a regular basis and weather-independent. The exercise, similarly to a live horse riding, causes alternating body movements of the to and fro type, such as inclinations and stretches of the pelvis, leg dangling, and spine rotations.

The goal of the present study was to assess the effect of mechanical horse riding-like exercise on the skin temperature responses in lower limbs of children with symmetrical or unilateral spastic cerebral palsy. We selected the lower limbs on the premise that they are subjected to the highest temperature variability due to spastic palsy-related changes. We hypothesized that rhythmic lower body and leg motion influences limb circulation, which would be reflected in skin temperature alterations.

**MATERIAL AND METHODS**

The study was accepted by an institutional Ethics Committee and informed consent was obtained from both the enrolled children and their care givers. Sixteen children suffering from cerebral palsy (7 girls and 9 boys) aged 14-16 (mean 9.3 ±3.8SD) were enrolled into the study. Spastic diplegia was diagnosed in 7 and unilateral palsy in 5 children. The remaining cases were composed the cerebellar syndrome and partial disruption of the spinal cord. Children performed the mechanical saddle exercise with undressed lower limbs, after a 10-min adaptation time. They sat in the saddle for 15-35 min, mean 20 ±5 min. Temperature was measured on the front limb surfaces before and immediately after cessation of exercise using a thermovision infrared camera, AGEMA 550 (FLIR Systems, Portland, OR, USA). Temperature readings were collected at points that ran along the dorsalis pedis, femoral (medial midmost part), and popliteal arteries. All temperature measurements were referenced to the temperature of the knee cap. The thermographic method has been previously applied for temperature measurements in brain (6-8) and internal diseases (9), or other conditions, including the skin surface (10).

Temperature values are given as means ±SE. Temperature differences between two legs of an individual before and after exercise, and concerning the corresponding leg in the control and exercise conditions were compared with a paired t-test. P<0.05 was considered to indicate significant differences.
RESULTS

In the present study, skin surface temperature before and directly after exercise in a mechanical saddle was recorded. In case of unilateral palsy, the reference for the paralyzed limb constituted the corresponding areas of a contralateral unaffected limb. Temperature distribution and values at the points of measurements are exemplified in thermograms presented in Fig. 1A and B.

We found that in unilateral palsy, the mean skin temperature on the dorsal foot surface before mechanical hippo-exercise was 32.0 ±0.8°C in the healthy leg and 30.5 ±1.3°C in the paralysis-affected leg; the difference between the two legs was borderline significant (P=0.05). After exercise, the skin temperature dropped to 30.5 ±0.7 and to 29.2 ±1.2°C in the healthy and affected legs, respectively (Fig. 2, Panels A and B). Thus, the temperature drop in both legs was grossly similar, by about 1.3-1.5°C, and the pattern of temperature differences between the healthy and diseased legs remained unchanged, with lower temperature in the

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**Fig. 1.** Exemplary thermographic recordings. Front view of lower limbs in a child with left-sided spastic palsy. Skin surface temperature distribution: A - before and B - after exercise in a mechanical saddle.

**Fig. 2.** Differences in skin temperature at the dorsal foot area in healthy and paralyzed legs before (A) and after (B) mechanical hippo-exercise in children with unilateral spastic palsy.
The temperature drop in the healthy leg due to exercise was statistically significant (P<0.05), as opposed to the paralyzed leg in which the drop, albeit in the same range, did not reach the level of significance because of wider spread of the measured temperature values.

In case of cerebral diplegia, the starting mean skin temperature of both legs was in a range of 31°C, which was about 1°C lower than that of the healthy leg in the unilateral palsy group. Mechanical hippo-exercise caused a further temperature drop, which, on average, ranged from 0.6 to 0.8°C (Fig. 3 and 4). The pattern of temperature changes was alike, regardless of the point of temperature read-out on the leg surface. There were no significant differences noted between both legs either before or after exercise.

**DISCUSSION**

The effects on the skin temperature responses of hippotherapy in children with cerebral palsy have not yet been studied. Since artificial mechanical hippotherapy
is an increasing choice in climate-restricted countries, it seemed warranted to test
the potential applicability of this therapeutic modality in rehabilitation of cerebral
palsy. The present study demonstrates that imitation of horse riding on a
mechanical device, which is a kind of motion exercise that involves the trunk, the
hips, and the legs, is a strong enough stimulus to induce physiological responses
in children with gross motor dysfunction. We noted decreases in skin temperature
recorded on the surface of lower limbs, both healthy and paralyzed, directly after
this type of exercise in children with spastic cerebral palsy.

Regulation of skin temperature is a complex process which, to a great extent,
depends on skin blood flow that, in turn, is a reflection of arterial blood
circulation in deeper limb tissue. Skin temperature should respond to exercise, as
exercise is expected to increase blood flow to muscles and to generate heat.
Studies on the skin temperature responses to exercise in healthy conditions have
given contentious results. Several authors demonstrated initial rapid decreases in
skin temperature with subsequent increases later on (11, 12). Such effects could
be explained by blood flow diversion from the skin to the exercising muscles at
exercise onset, with the predominance of thermal vasodilation, conducted to the
skin and overriding the vasoconstrictive effects during sustained exercise. Others
(13), however, noted an outright increase in skin blood flow at the onset of
exercise, which should involve an increase in skin temperature, although in the
quoted study thermal changes on the skin surface were unmeasured. An initial
drop in skin blood flow and, consequently, temperature concerns, in particular,
constant-load type of exercise, mechanical hippotherapy is one kind of, as
opposed to graded exercise in which an increase in skin temperature at the onset
of exercise is sustained throughout (10). In the present study, in which a relatively
short bout of mechanical hippo-exercise was employed, skin temperature was
decreased in both affected and unaffected with motor dysfunction lower limbs of
children with cerebral palsy. Our results would be in line with those showing an
exercise-related decrease in skin temperature (11, 12). However, the decrease we
observed was evident right after cessation of exercise, which makes rather
improbable the presence of a rise in skin temperature secondary to vasodilation
of sustained exercise. Plausibly, the continuous decrease in limb temperature is
caused by a continuous skin vasoconstrictive activity, persevering in children
with spastic palsy and being additionally enhanced by exercise.

We conclude that exercise, emulating horse riding, causes a sustained
lowering of skin temperature in children with spastic cerebral palsy, indicating
acutely diminished skin blood flow; a liable effect of intensified vasoconstriction.
Therefore, mechanical horse riding seems inadvisable as a means of improving
circulatory-related disturbances of gross motor function and coordination in these
children. The present study, however, does not exclude longer-term beneficial
effects of regular use of mechanical saddle exercise in both psychological and
physical realms. The effects of this type of mechanical hippotherapy in
rehabilitation of children with cerebral palsy remain to be further explored.
Conflicts of interest: The authors had no conflicts of interest to declare in relation to this article.

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