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Trapezius muscle tone and viscoelastic properties in sitting and supine positions

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Objectives In this study, the aim was to use the upper trapezius muscle as a representative of the musculoskeletal support system to determine the effect of changing from a sitting position to a lying position on muscle tension and whether this change could be useful in the prevention of musculoskeletal complaints.
Methods Fifteen healthy right-handed female computer operators participated in this study. Myometric measurements of the upper trapezius muscle on both sides of the body were recorded for the participants while they were in a sitting position and then again in a supine position.
Results Changing from a sitting position to a supine position reduced the tone and stiffness by up to one-fifth—important characteristics of the support function—in the upper trapezius muscle.
Conclusions The change in the tone and stiffness of the trapezius muscle is of significance to the well-being of sedentary workers, particularly computer-terminal operators. Including recommended regular breaks of brief periods of simple, unchallenging movements while in a supine position should enhance their recovery from prolonged sitting because the support requirement on the muscles is lessened.

Key terms gravity; muscle tone; sitting; support function; workplace prevention.

As early as 1700, Bernadino Ramazzini (1) observed that the chief cause of health problems in clerks was their constant sitting. But the significance of this observation was lost in the intervening three centuries. The contemporary equivalents of his clerical workers are computer terminal operators. Kamwendo et al (2), in 1991, and Skov et al (3), in 1996, suggested that there is a relationship between sitting posture and neck pain. This relationship was confirmed by Cagnie and her colleagues (4) in 2007. Moreover, Ariëns and her colleagues (5) have shown that being seated for 95% of one's work period, that is to say, the length of time spent sitting, is, in itself, an independent risk factor for the development of neck pain. There are, of course, additional risk factors for neck pain in computer operators, such as nonneutral postures and psychosocial factors. However, even when all of these factors are taken into consideration, the reason for the phenomenon itself is not yet clear.

There have been various suggestions for trying to reduce and manage the incidence of upper-body complaints among terminal operators, including the redesigning of workstations to make them more user-friendly (6). But there may be a much simpler and cheaper way, one which is very easy to implement. It is our contention that there needs to be greater awareness of the role that muscles play in supporting the body under gravitational forces. It may be that an examination of this phenomenon could lead to an important understanding. Rather

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than focusing on excessive sitting as the problem, we might more fruitfully concentrate on devising ways of optimizing the recovery from this undesirable state.

We believe that the very role of the muscles in supporting the body in a sitting position under the force of gravity should be considered.

There is currently a great deal of anecdotal evidence that the inclusion of regular breaks incorporating exercise has a positive effect on upper-body complaints, but there is limited objective evidence (7). Once there is empirical evidence in place, we can begin to formulate possibly innovative strategies for both the treatment and prevention of work-related neck and shoulder disorders among sedentary workers.

Our contribution to this investigation has been to focus on the upper trapezius muscle in its low load-bearing and voluntary uncontracted condition. We measured tone and viscoelastic property, in both sitting and supine positions, and compared the results.

Study population and methods

Study population

The participants were 15 healthy right-handed female computer operators. The mean anthropometric characteristics were age 27 years (SD 3.5) years, weight 55.6 (SD 5.6) kg, and height 168 (SD 6.0) cm. Each of the participants gave their informed written consent. The study was vetted by the Ethical Committee of the Päijät–Häme Hospital District to ensure that it was conducted under the terms of the Declaration of Helsinki.

Methods

The same four-legged wooden chair with a padded backrest and seat, without armrests, and without height adjustability was used throughout step 1. An examination couch was used for step 2. A nontoxic marker and a myometric device were employed for the measurements.

In step 1, each participant sat in a comfortable relaxed upright position, hands in lap. They were asked to focus on a mark 200 meters away in order to fix the tilt of the head and the angle of the neck. Nontoxic marks were highlighted on the skin above the middle of the upper trapezius belly halfway from the acromion to the seventh cervical (C7) process. Then the myometric device (figure 1), as fully described by Vain et al (8) and Gavronski et al (9), was applied to the marks, and 20 consecutive measurements (at an interval of 1–2 seconds between each) were done on both sides of the body.

In step 2, the same measurements were taken, but, in this case, the participant lay comfortably supine on a padded examination table. The measurements were done in series, lasting 8–10 minutes, including 3 minutes of horizontal positioning and relaxation between steps 1 and 2.

Then we compared the results obtained in the sitting position with those obtained in the supine position. The differences, significant at the 95% level, are reported

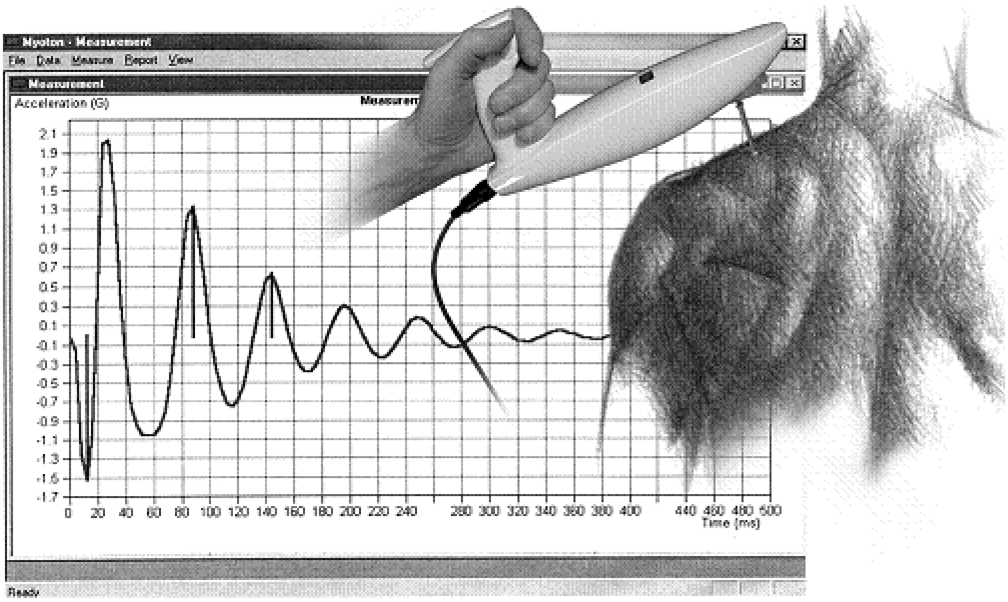

Figure 1. The Myoton device and an illustration of the myometric measuring method (10). The principle of myometry lies in giving the muscle under investigation a dosed local mechanical impulse shortly followed by quick release, and recording the mechanical response of the muscle. [Figure reprinted with the permission of R Viir, K Laiho, J Kramarenko, and M Mikkelsson and the World Scientific Publishing Co Pte, Ltd, Singapore; figure designed by IVO-Ott Hirvesoo]

on the basis of a Student's t-test. SAS software (release 8.02, http://v8doc.sas.com/sashtml/) was used for the analysis. Graphics were done with R, version 2.4.1 (http://www.r-project.org/).

Measurement of mechanical properties. The mechanical characteristics of the upper trapezius muscles were recorded by the damping oscillation method using a handheld Myoton myometer (Müomeetria Ltd CE0537, Tartu, Estonia). The reliability and repeatability of this device and method have been confirmed by Viir et al (10) and Bizzini & Mannion (11). The device has a weight of 4.0 kg and functions in conjunction with a compatible personal computer.

Briefly, the Myoton device is an apparatus for registering mechanical oscillations of the tissue provoked by the device itself—the testing-end component of the apparatus works also as a sensor for tissue response. An acceleration transducer, situated on the testing-end, allows the muscle deformation evoked by mechanical impact (0.4 N) to be recorded. Because the neural activation of the skeletal muscle may occur after 25 ms and the properties of the muscle may change (12), the duration of the impact is set at 15 ms to avoid neural reactions and nonelastic deformations of the tissue. In response to the given impact, the tissue (in our case, muscle tissue), together with the testing end, performs natural damping oscillations, governed by the viscoelastic properties of the biological tissue.

Muscle tone and established parameters. The term "muscle tone" is used to describe the mechanical firmness of skeletal muscle that exists when the muscles are in a steady-state condition, with no voluntary contraction, and can be characterized by certain mechanical properties of the muscle (eg, stiffness and elasticity).

Three parameters were calculated, namely, frequency, stiffness, and elasticity. The frequency of the damping oscillation characterizes the state of the tissue under mechanical stress. The higher the value (Hz), the tenser the muscle. Muscle tension increases through both contraction and stretching. By definition, the oscillation frequency of the nonactive muscle is muscle tone.

Stiffness reflects the resistance of the tissue to the force that changes its shape. The higher the value (N/m), the more force is needed to modify the shape of tissue. During contraction or loading, the stiffness of skeletal muscle increases.

Elasticity is the ability of tissue to recover its shape after contraction, and it is characterized by the (unit-less parameter) logarithmic decrement of the oscillation. It describes how much mechanical energy is dissipated in this damping. The smaller the value, the more elastic the tissue. The higher the value, the more energy dissipated and the less elastic the tissue. Opposite to elasticity is plasticity—the body holds the shape it is given.

Whereas electromyography registers the parameters of electrical activity of the skeletal muscle, the parameters measured by the Myoton device reflect the conditions (ie, the workability restoration time of muscles during work and after it), and the character of mechanical tension transmission from the sarcomere to the bone levers (13).

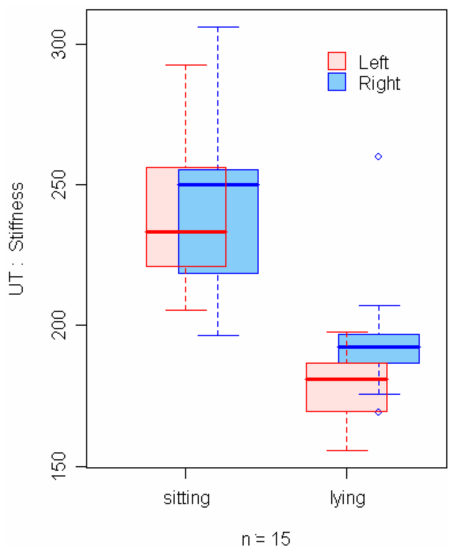

Figure. 2. Box plot representing the stiffness of the upper trapezius muscle (UT) (N/m, Y-axis) in sitting and supine positions to compare average levels.

Results

The individual measurement results were combined for each position, and the similarity to normal distribution appeared. The results of the Student's t-tests follow. The box-and-whisker plot method (14) was used because it can combine a display of all the data together with a statistical summary and the concise graphs are easily interpreted. The interquartile range contains the middle 50% of the data and is shown by the length between the outer edges of the box. The whiskers in the box plot extends to the most extreme data point, which is no more than 1.5 times the interquartile range from the box (quartiles). Points farther than 1.5 times the interquartile range are plotted individually.

For the whole group, the stiffness of the upper trapezius muscle appears to be lower in the supine position than in the sitting position on both body sides: from 242 (SD 33.2) N/m to 195 (SD 21.2) N/m on the right side of the body and from 239 (SD 27.4) N/m to 179 (SD 13.1) N/m on the left side. The decrease on both sides was statistically significant (left: t=9.50, P<0.0001; right: t=7.49, P<0.0001; one-sided tests) (figure 2).

The values for the tone of the upper trapezius muscle decreased on the right and left sides from 13.1 (SD1.1) Hz to 10.8 (SD 0.6) Hz and from 12.9 (SD 1.1) Hz to 10.1 (SD 0.8) Hz, respectively. The decrease on both sides was statistically significant (left: $t = 13.79$, $P<0.0001$; right: $t = 6.37$, $P<0.0001$; one-sided tests) (figure 3).

No significant change (left: $t = –0.37$, $P=0.714$; right: $t = –1.59$, $P=0.135$; two-sided tests) appeared in the elasticity of the upper trapezius muscle (figure 4).

Discussion

It seems obvious from our knowledge of the musculoskeletal support system, as well as from observation and touch, that there is a difference in tension in muscle under the force of gravity when in a sitting position and when lying down. Yet, oddly enough, there has been no prior direct measurement of this difference.

We have found a measurable difference, which seems robust in that the differences were evident for each participant, and, in most cases, changes in tone and stiffness were measurable on both sides. The fact that a change in elasticity was not shown by all of the participants, although it did appear in most of them, highlights the reality that there is significant personal variability in this particular aspect.

The immediate decrease in the tone and stiffness of the upper trapezius muscle, which occurs with a change from a sitting position to a supine position, clearly demonstrates that the sitting position requires greater tension and stiffness to maintain. Computer terminal operators, in particular, tend to sit still for an inordinate length of time. If one includes the duration of time as a factor to be considered in the overall phenomena, then the resulting tension, stiffness, and upper-body problems are not surprising.

The incapacity to correlate and integrate the mechanical properties of muscles and tension with motor control effects and the role of different levels of the electromyographically assessable muscle activity is a limitation in our study. In whatever way one describes the steady-state muscle tension (which ensures the sitting position)—the voluntary or nonvoluntary contraction, or also the so-called unnecessary component of tension, all analyzed by Simons & Mense (15)—the fact is that declining to a horizontal position gives a prompt, measurable decrease in this tension.

Proper appreciation of this simple phenomenon may lead to new ways of treating and preventing work-related neck and shoulder disorders in sedentary workers. It seems plausible to suppose that many of the gentle movements performed in the supine position may result

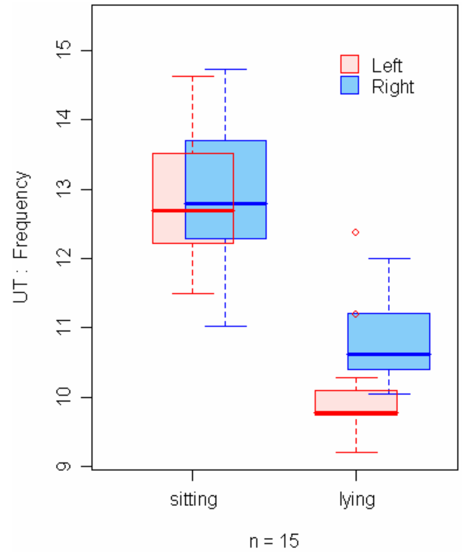

Figure 3. Box plot representing the tone of the upper trapezius (UT) muscle, characterized by the oscillation frequency (Hz, Y-axis) in sitting and supine positions to compare average levels.

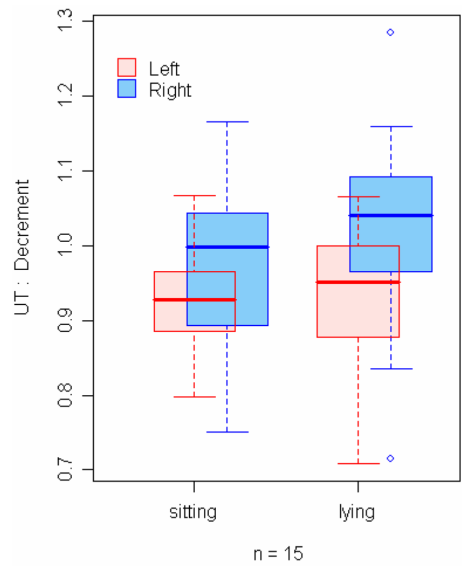

Figure 4. Box plot representing the elasticity of the upper trapezius (UT) muscle, reciprocally characterized by (unit-less parameter, Y-axis) the logarithmic decrement of damping in sitting and supine positions to compare average levels.

in different effects with respect to micro and macro circulation, as compared with those done in semi- or upright positions. For instance, it is already known that flexing the feet while lying down more than doubles the lymph flow, as compared with the rate of flow achieved when exercising in other, upright positions (16). In addition, the fact that stiffness decreases when a person lies down may mean that the circulation of blood and lymph in the body itself is also similarly enhanced when the gravitational load is decreased.

Otium reficit vires: rest restores vitality. We postulate that the determination of the appropriate ratio between lengthy sitting and periods of recovery is crucially significant to all sedentary workers, particularly computer operators. But it is not solely a matter of rest. It is important to clarify the timing, duration, and type of relaxation and exercise that would yield the speediest possible recovery for muscles held too long in a fixed sitting position. We have some preliminary findings (outside the scope of this paper) showing that, as little as 2 minutes of gentle movement at each break, performed regularly each hour, with the worker lying down, could ameliorate the effect of prolonged sitting and restore tone to the muscles. However, the movements must be specific, simple, and unchallenging. These exercises could be performed either on couches or on a personal yoga mat or a large towel. All the employer would have to provide is sufficient clean, dedicated space, and perhaps a few couches, enough that every worker would have access hourly for 5 minutes at a time on a rostered basis.

The encouragement of a regime of simple, cheap, noninvasive, nonchallenging movements would seem to be of great potential significance in preventing upper-body disorders in sedentary workers.

It ought to appeal to employers as well, given that, in addition to the useful attributes enumerated in this paper, such a regime would have the further advantages of being efficient in the use of time, and also cost-effective in that it does not require any special facilities, instructor, or occupational therapists. Only one couch or exercising mat is needed for 10 people per hour to perform these simple recovering movements on a rostered schedule (17).

Further studies will be required to test whether the findings of our modest sample, and our suggestion for 2 minutes of simple nonchallenging movements per break for sedentary workers, to be performed in a lying position, will prove correct and will achieve the preventive effect postulated by us.

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