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ORIGINAL ARTICLE

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The influence of different intermittent myofeedback training schedules on learning relaxation of the trapezius muscle while performing a gross-motor task

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Abstract The aim of this study was to investigate the influence of different intermittent myofeedback training schedules, as provided by a Cinderella-based myofeedback system, on learning relaxation and resistance to extinction of the trapezius muscle, in subjects performing a unilateral gross-motor task. Eighteen healthy subjects performed the task without and with feedback to study baseline and learning relaxation. Subsequently, resistance to extinction was investigated by performing the task without feedback. The gross-motor task consisted of continuously moving the dominant arm between three target areas at a constant pace. Subjects were randomly assigned into three groups, characterized by the sequence of feedback schedules with which the task was performed on 3 consecutive days. Auditory feedback was provided after a 5-, 10-, or 20-s interval when a pre-set level of 80% rest was not reached. Bipolar surface electromyography recordings performed at the dominant upper trapezius muscle were quantified using relative rest time (RRT) and root mean square (RMS) parameters. Learning relaxation was defined as an increase in RRT and a decrease in RMS values. Results showed the highest RRT levels as well as a decrease in RMS for the 10-s schedule. Additionally, the 10-s schedule was unique in its ability to elevate muscular rest above the 20% level, which may be considered relevant in preventing myalgia. None of the three schedules showed resistance to extinction. It was concluded that the 10-s interval was preferred over the 5- and 20-s schedules in learning trapezius relaxation in subjects performing a unilateral gross-motor task.

Keywords Myofeedback training · Intermittent reinforcement · Surface electromyography · Trapezius relaxation

Introduction

Biofeedback can be defined as ‘the use of monitoring instruments (usually electrical) to detect and amplify internal physiological processes within the body, in order to make this ordinarily unavailable internal information available to the individual and literally feed it back to him in some form’ (Birk 1973). Feedback is important in the field of learning theories since it can be considered a form of operant conditioning, as described by Skinner (1953). One of the most important topics of operant conditioning for the process of learning is the schedule of reinforcement (Cohen et al. 2001). These schedules describe the relationship between responses and their consequences (Ferster and Skinner 1957) and can be classified into two groups: continuous reinforcement and partial, or intermittent, reinforcement. According to Schwartz and Andrasik (1995), continuous reinforcement, providing feedback after every correct response, is the most frequently used schedule. Intermittent reinforcement is characterized by interval or ratio reinforcement. With interval schedules, feedback is

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given after a certain period that can be fixed or variable. Although several studies showed that continuous reinforcement results in larger physiological adaptations compared to intermittent schedules (Gamble and Elder 1990; Cohen et al. 2001; Sangha et al. 2002), it appeared to be less resistant to extinction (i.e. Skinner 1938; Mackintosh 1974; Cohen et al. 2001; Sangha et al. 2002).

In health care, biofeedback has frequently been used in breathing therapies (e.g. Schwartz 1995a), changing heart rate (e.g. Brener et al. 1969), the reduction of tension headaches (e.g. Schwartz 1995b), and hypertension (e.g. McGrady et al. 1995). In rehabilitation it could be effectively applied for neuromuscular re-education, for example improving muscular strength after stroke (Moreland et al. 1998), or diminishing muscular tension in order to reduce (Fogel 1995; Nord et al. 2001) or prevent work-related musculoskeletal complaints (Faucett et al. 2002). Biofeedback in neuromuscular re-education is usually called myofeedback. In the case of reducing muscle tension, most myofeedback interventions that are used in practice are directed at a muscular activity level (root mean square, RMS), for instance feedback is given when muscular activity exceeds a certain level. The rationale behind this is the assumption that higher muscle tension affects the muscle blood flow and transport of supply and metabolites (van Steenis and de Winter 1997) resulting in myalgia. However, Veiersted et al. (1993) showed the development of pain in 1% maximal voluntary contraction (MVC), so the restriction of muscle blood flow can probably not be held responsible for muscular pain in, for instance, patients with work-related musculoskeletal disorders. The Cinderella hypothesis formulated by Hägg in 1991 gives an alternative explanation for the development and persistence of myalgia. It encompasses the idea of a fixed motor-unit recruitment and de-recruitment order in repeated muscle activation, also called Henneman's size principle (Henneman et al. 1965), for which evidence was also found in patients with muscular disorders related to occupational static loads (Henriksson 1988; Hägg and Åström 1997). Too little relaxation will damage especially the low threshold motor units (type 1 or Cinderella motor units) as they are always recruited first and remain active until total relaxation of the muscle occurs (Hägg 1991). The absence of short periods of muscular rest has been considered as a potential risk factor in the development and persistence of muscular pain (Lundberg 1999; Nederhand et al. 2000; Sandsjö et al. 2000).

Based on this, one could conclude that feedback should be provided when muscular relaxation is lacking, thereby teaching subjects to increase their level of muscular rest. In one of the first studies with a Cinderella-based myofeedback system, feedback was based on lack of upper trapezius muscle relaxation instead of activation levels that were too high (Hermens and Hutten 2002). It was shown that this form of myofeedback training results in an increase in muscular relaxation and a decrease in muscular activation and neck/shoulder pain in the majority of patients with work-related musculoskeletal complaints after a 4-week period of training (Hermens and Hutten 2002). The feedback interval chosen in the study was 10-s, but it was not investigated whether this was the optimal time interval. More generally, no research has been found investigating the reinforcement schedules for this form of myofeedback training. Therefore, the aim of this study was to investigate the influence of different intermittent myofeedback training schedules, as provided by a Cinderella-based myofeedback system, on learning relaxation of the trapezius muscle. The major goal was to identify the influence of different intermittent myofeedback schedules on learning trapezius relaxation, as well as its resistance to extinction.

Methods

Subjects and design

Able-bodied subjects between 18 and 60 years of age were selected by means of a short checklist concerning complaints in the neck and shoulder region during the previous year, month, and week. Subjects were eligible when reporting a pain-free period of at least 1 month before measurement. In addition, neck/shoulder complaints were allowed to be present for a maximum of 7 days during the previous year. Subjects were excluded if they suffered from severe cervical arthrosis, joint disorder(s), latex allergy, or deafness. Recruitment was performed among employees at the National Institute for Working Life/West, Göteborg, Sweden and Roessingh Research and Development, Enschede, The Netherlands. The study was approved by the medical ethical committee.

The study was set up as a multiple cross-over trial. In total, 20 subjects were recruited and they were randomly assigned into three groups (A, B, or C), each receiving a different order of the intermittent feedback schedules under investigation. After this randomization, two subjects were excluded; one for motivational reasons and the other due to illness. In the end seven subjects were assigned to group A (five female, two male), five to group B (two female, three male), and six to group C (four female, two male). Subjects were between 21 and 57 years of age [mean (SD), 30.3 (9.7) years] with a mean (SD) height of 1.80 (0.10) m (range 1.6–2.0) and a mean (SD) body mass of 73.4 (8.9) kg (range 63–89). The body mass index varied from 19.9 to 29.1 [23.1 (2.1)]. Two of the 18 subjects were left-handed.

Surface electromyography (sEMG) detection and myofeedback

sEMG was recorded from the dominant upper trapezius muscle. Besides a postural and supporting function, the trapezius muscle is important for adjustment of the scapula during elevation of the upper arm (Basmajian and De Luca 1985) and its superficial location makes it highly suitable for sEMG recordings and feedback applications.

Before electrode placement, the skin was cleaned with alcohol. Adhesive surface electrodes (Arbo H93, solid gel, inter-electrode distance 2.5 cm) were placed 2 cm laterally to the midpoint between C7 and the lateral end of the acromion (Jensen et al. 1993), and the position of the electrodes was marked with a semi-permanent marker to ensure identical placement of electrodes during measurements on consecutive days.

The sEMG signal was amplified (×15), digitized (22 bits ADC), and smooth rectified with removal of the low-frequency components. Sample frequency was 512 Hz and the signal was band-pass filtered between 30 and 250 Hz. This specific filter setting was chosen in order to avoid the effects of movement artifacts in the calculation of relative muscular rest time (RRT) and to avoid false results related to the low sample rate. Embedded software provided muscle rest detection and parameterization. RRT was defined as the percentage of time in which RMS was below threshold (10 μV for at least 0.120 s). This threshold was based on the noise level of the myofeedback system, including mounted electrodes on the skin. Auditory feedback was provided after a fixed interval when the relative duration of muscle relaxation in that interval was less than 80%. The 80% threshold was based on earlier observations, which indicated that, in general, subjects who have the ability to relax showed RRT values above 80% during computer-related tasks, while subjects with an inability to relax showed RRT values below 20%. The system was connected to a computer and data were stored for off-line analysis.

Protocol

Three different interval schedules were chosen for providing feedback, i.e. 5-, 10-, and 20-s. This means that feedback was provided after 5-, 10-, or 20-s when the relative duration of muscle relaxation was shorter than 80% during that interval. Taking the 5-s interval schedule for example, whether or not feedback should be provided was evaluated after each fifth second. If the level of relative muscle relaxation was below 80% during that 5-s period, auditory feedback was provided to the subject.

Each subject was exposed to each interval schedule on 3 consecutive days and the sequence of the feedback intervals was randomized. Figure 1 shows the order in which feedback intervals were presented to the three subject groups (A, B, and C) on the 3 consecutive days.

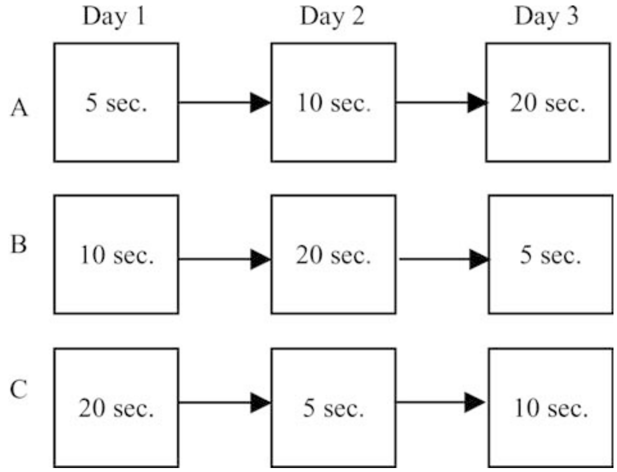

Fig. 1 Schematic overview of study design

Participants were seated behind a table in a chair without arm support. The height of the table and the chair were then adjusted so that elbow flexion of the dominant arm was within a range of 90–95 degrees when the upper arm was held along the body with the forearm placed on the table, since an angle of less than 90 degrees would cause undesired trapezius activation due to elevation of the shoulder when moving the forearm and hand above the table. Participants performed a unilateral gross-motor task in which they had to move the dominant arm continuously between three target areas by putting marks with a pencil in circles with a diameter of 12 mm (see Figure 2).

Right-handed subjects moved the dominant arm from the left target via the upper to the right target, while left-handed subjects, in contrast, had to move the dominant arm from the left target via the right to the upper target to ensure anatomical similarity in movements between the two groups. The upper target was immediately in front of the subject, and the distance between the subject and the upper target was such that the elbow did not have to extend fully to reach the target. Pace was kept constant at 88 marks min^{-1} with the help of a metronome (Nederhand et al. 2000).

Subjects were informed that this study aimed at investigating the influence of different feedback schedules on muscular relaxation. They received no information about the different schedules used in order to avoid information bias. Subjects were not allowed to talk during recordings.

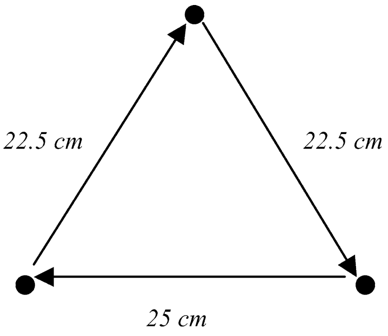

Fig. 2 Gross-motor task, direction of moving the dominant arm in right-handed subjects

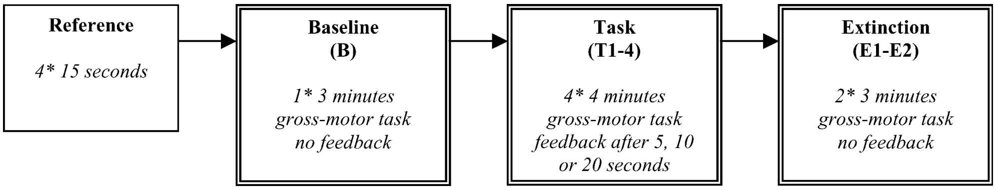

Fig. 3 Schematic overview of surface electromyography recordings

The sEMG recordings (see Figure 3) started with four reference contractions of the trapezius muscle performed according to the guidelines of Mathiassen et al. (1995).

These reference contractions were followed by a gross-motor task during 3 minutes without myofeedback to study baseline (B). Subjects were instructed that they had to perform the task with the upper extremity (especially the dominant shoulder) as relaxed as possible with the non-dominant arm resting on the table.

Subsequently subjects performed the gross-motor task with feedback during 4 minutes four times (tasks; T1–T4). In between each measurement there were 2 minutes of rest to prevent subjects from muscle overload. Subjects were instructed that they had to discover a way of performing the task that would result in the fewest feedback signals and that this could be reached by relaxation. Again, the non-dominant arm was resting on the table. These tasks were considered the learning phase.

A 3-minutes gross-motor task without myofeedback was performed twice to study resistance to extinction (E1 and E2), again with 2 minutes rest in between. Instructions were identical to those given during baseline measurement.

Data analysis

Learning trapezius relaxation was defined as an increase in relaxation as well as a decrease in activation expressed in sEMG outcome parameters RRT (%) and RMS (μV). RRT was defined as the percentage of time in which RMS was below 10 μV for at least 0.120 s. sEMG was continuously recorded during baseline, tasks, and extinction measurements, and both RRT and RMS were calculated in consecutive periods of 20-s. This resulted in nine baseline values, 4×12 task values, and 2×9 extinction values for each parameter. These values were subsequently averaged resulting in one value for baseline (B), one for each task (T1, T2, T3, T4), and one for each extinction measurement (E1 and E2) for each parameter per subject.

RMS values of the reference contractions were computed for the middle 10-s of each contraction (Mathiassen et al. 1995) and the mean value was used for normalization. This means that RMS values during baseline, tasks, and extinction measurements were expressed as percentages of this mean reference value. After this normalization procedure, individual values were averaged to obtain group results: $n = 18$ for the 5-, 10-, and 20-s intervals for RRT, and $n = 13$ for RMS. RMS values for five subjects were missing due to technical problems with the recording system.

Statistical analysis

Surface EMG parameters were tested for normality using the Shapiro–Wilk test indicating a non-normal distribution for RRT values ($p < 0.05$) and a normal distribution for RMS values ($p > 0.05$).

Statistical analysis was divided into two parts. Firstly, it was investigated whether the three different interval training schedules resulted in different RRT and RMS values at baseline, T1–T4, and E1 and E2. For RRT values a non-parametric method based on rank statistics was used, and for RMS a test for multiple cross-over trials based on linear mixed-effects modeling was used. Secondly, for each separate feedback interval, it was investigated whether RRT and RMS values changed during the tasks (T1–T4) compared to baseline in order to study the learning pattern for each interval, and whether E1 and E2 differed compared to baseline and T4, in order to study resistance to extinction. For RRT, Friedman tests (*k* related samples) and Wilcoxon signed rank tests (two related samples) were used, while RMS analysis required paired sample *t*-tests.

Alpha was set at 0.05 for statistical significance.

Results

Muscular relaxation

Figure 4 represents the course of RRT for each interval. Additionally, median RRT values and corresponding 25th–75thquartiles are presented in Table 1.

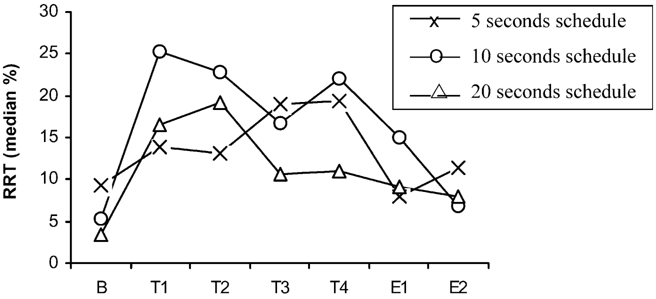

Fig. 4 Relative muscular rest time (*RRT*) values of the trapezius muscle induced by the three different interval schedules during gross-motor task performance. *B* Baseline, *T* Task, *E*Extinction

Table 1 Relative rest time (RRT): median (25th–75th quartiles) per interval for baseline, tasks 1–4, and extinction 1 and 2 measurements

Interval	Baseline	Task 1	Task 2	Task 3	Task 4	Extinction 1	Extinction 2
5 s	9.4 (0.3–17.9)	13.9 (2.5–49.7)	13.1 (8.1–30.2)	19.0 (10.2–47.5)	19.4 (8.4–54.1)	8.0 (3.7–46.8)	11.5 (1.6–39.3)
10 s	5.3 (0.5–39.7)	25.2 (3.3–53.9)	22.8 (5.7–63.2)	16.7 (4.5–42.4)	22.1 (2.9–51.7)	15.0 (2.6–36.2)	6.9 (1.4–35.3)
20 s	3.4 (0.3–45.4)	16.6 (2.3–54.0)	19.2 (5.1–53.6)	10.7 (1.7–45.5)	10.9 (4.7–52.5)	9.1 (1.6–44.6)	8.0 (1.0–42.7)

Results showed a tendency of increased RRT values during the feedback tasks (T1–T4) compared to baseline for the 5-, 10-, and 20-s interval schedules. During the extinction measurements (E1 and E2), RRT values were comparable to baseline for each interval.

Overall statistical testing for interval and measurement as independent factors showed significant differences. Post-hoc testing revealed no significant differences in RRT values between the three intervals during baseline, tasks, and extinction measurements (*p* value range 0.40–0.95). However, significantly changed RRT values were found for each interval during the tasks compared to baseline ($p = 0.00$).

The 5-s interval induced significantly increased RRT values during T1–T4 compared to baseline ($p \leq 0.05$). For the 10-s interval, RRT values at T1 and T2 were significantly higher compared to baseline ($p \leq 0.01$), and for the 20-s interval, relative muscular rest time values were significantly increased compared to baseline at T1 only ($p \leq 0.02$). Looking at the absolute levels of rest time, the 10-s feedback interval resulted in the highest RRT values (25%) compared to the other two schedules, and also the steepest increase at the beginning of the measurement.

When the gross-motor task was performed after the learning period without feedback in order to study resistance to extinction, RRT values were identical to baseline for each interval (*p* value range 0.31–0.88). This suggests that none of the three schedules was effective in retaining muscular relaxation as learned during the tasks. Compared to T4, muscular relaxation at E1 and E2 was significantly lower for the 5-s schedule ($p \leq 0.01$), while only E1 was significantly lower at the 10-s schedule ($p = 0.02$) and E2 at the 20-s schedule ($p = 0.03$).

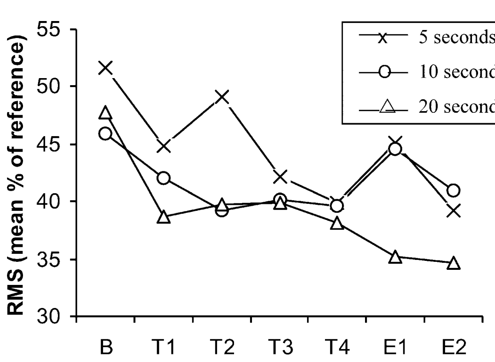

Fig. 5 Root mean square (*RMS*) values of the trapezius muscle induced by the three different interval schedules during gross-motor task performance. *B* Baseline, *T* Task, *E* Extinction

Muscular activation

Figure 5 represents the course of RMS for each interval. In addition, mean RMS and the corresponding SD values are displayed in Table 2 for each interval separately.

Results showed a trend of decreased RMS values during T1–T4 compared to baseline for the 5-, 10-, and 20-s interval schedules. After ending the feedback, muscular activity increased considerably during the 5- and 10-s interval schedules, but not during the 20-s schedule.

A linear mixed-effects model showed no statistical differences between the three intervals at baseline, T1–T4, and E1 and E2 ($F = 0.121; p = 0.89$). However, significant differences were found within intervals between baseline, tasks, and extinction measurements ($F = 2.892; p = 0.01$).

Post-hoc testing showed that for the 5-s interval, muscular activation during T1–T4 was not different compared to baseline (*p* range 0.08–0.16). The 10-s schedule resulted in significantly changed RMS values during T2 compared to baseline ($p = 0.04$), but not during the other tasks (*p* range 0.09–0.43). Providing feedback after 20-s resulted in changed muscular activation levels at T1 and T2 compared to baseline ($p = 0.03$ and $p = 0.02$ respectively).

The level of trapezius activation for each interval during both extinction measurements was not significantly different from baseline (*p* values range 0.14–0.70). For the 5-s interval, RMS values were significantly different compared to T4 at E1 ($p = 0.04$), but not at E2. The 10-s interval resulted in significantly higher E1 values compared to T4 ($p = 0.01$), but this change was absent during the second extinction measurement ($p = 0.53$). Finally, for the 20-s schedule, there were no differences in muscular activation after the feedback training compared to T4.

Discussion

This multiple cross-over study aimed at increasing knowledge about the influence of different intermittent myofeedback schedules on learning relaxation of the trapezius muscle during a gross-motor task, as well as its resistance to extinction, using a Cinderella-based myofeedback system.

The 10-s schedule resulted in the highest level of muscular relaxation (RRT). This schedule also appeared to be unique in its ability to increase RRT above the 20% level. Based on the study of Hägg and Åström (1997), in which EMG recordings were performed at the

Table 2 Root mean square (RMS): mean (SD) values per interval for baseline, tasks 1–4, and extinction 1 and 2 measurements

Interval	Baseline	Task 1	Task 2	Task 3	Task 4	Extinction 1	Extinction 2
5 s	51.7 (34.0)	39.9 (23.2)	47.6 (28.9)	42.2 (21.0)	39.7 (25.1)	45.1 (29.5)	38.5 (17.6)
10 s	45.9 (27.1)	42.0 (35.8)	39.8 (31.2)	42.2 (31.2)	39.7 (32.0)	44.6 (33.8)	44.1 (27.6)
20 s	47.8 (37.6)	37.3 (27.3)	39.8 (31.6)	39.9 (26.1)	39.1 (24.7)	34.9 (21.9)	34.7 (18.0)

upper trapezius muscle in medical secretaries with and without complaints, this 20% level of muscular relaxation may be considered as relevant in preventing from the development of myalgia.

Muscle activation (RMS) was least affected by the 20-s schedule. The change in muscular activation was limited during the feedback training and also the initial effect of increased relaxation (RRT) disappeared during the continuation of the measurements, which might indicate that the postulated effect of feedback was limited with this interval. One hypothesis to explain lack of learning occurring under partial, or intermittent, reinforcement schedules is the invariance hypothesis of Williams (1989), which suggests that the reduced number of reinforcement stimuli obtained during the learning phase is responsible for the learning deficit. In this study, the maximal number of feedback stimuli for the 20-s schedule is 12 per task, while for the 5- and 10-s schedule, the maximal number of stimuli is 48 and 24 per task respectively. The limited duration of the learning period in this study might well be responsible for the absence of learning effects with the 20-s schedule.

Based on this invariance hypothesis (Williams 1989), one could suggest that the 5-s schedule would be preferred over the 20- and 10-s interval schedules. Furthermore, the duration of this interval is so short that it approaches continuous feedback, which in several studies has been shown to be more effective in inducing physiological changes than intermittent feedback schedules (Gamble and Elder 1990; Cohen et al. 2001; Sangha et al. 2002). However, although the 5-s schedule induced increasing trapezius relaxation during the training period, median values were still below 20%. Furthermore, this schedule resulted in the highest level of trapezius activation compared to the 10- and 20-s schedules. A cause of this may be the mental stress evoked by this relatively high number of feedback stimuli. Lundberg et al. (1994) showed that mental stress does increase the level of activation in the trapezius muscle and, as such, this was also reported by the subjects after the tasks. This suggests that the 5-s schedule may be less effective in myofeedback training aimed at learning trapezius relaxation in stress-sensitive subjects, which probably concerns the majority of subjects with work-related myalgia.

Although intermittent reinforcement schedules are assumed to be more resistant to extinction (Skinner 1938; Mackintosh 1974; Cohen et al. 2001; Sangha et al. 2002), none of the three schedules used in this study proved to be resistant to extinction. This means that although subjects were able to increase relaxation and reduce activation levels during the feedback tasks, the feedback training did not result in a skill that they could use in a consecutive task without feedback. An explanation may be that the training period was too short to learn the motor skill that would result in a change of muscle activation patterns.

It can be questioned whether the content of the feedback used in this study results in optimal learning effects. The content of feedback was based on the knowledge of results principle, i.e. external information was provided about the outcome of the performance, implicating that feedback only gave information about whether the pre-set level of relaxation was reached or not (Magill 2001a). The theoretical counterpart is knowledge of performance, for example providing subjects with additional information about why they were not able to switch off the feedback by telling them that they may need to suppress the shoulder or reduce the amplitude of arm movement. Although some studies conclude that knowledge of performance is more influential in learning (e.g. Kernodle and Carlton 1992), others report that both ways of providing feedback are equally effective in general (Brisson and Alain 1997). However, knowledge of performance appeared to be especially effective when subjects have to adopt specific muscle activity (Magill 2001b).

In order to obtain the least amount of feedback, subjects used different strategies while performing the gross-motor task, varying from suppression of the shoulder to restricting the amplitude of arm movement. This could suggest that other muscles were activated in order to enable relaxation of the upper trapezius muscle. Evidence for this was found by Palmerud et al. (1995, 1998), who investigated whether subjects could effectively reduce trapezius muscle activity induced by continuous visual feedback techniques, and whether this relaxation was reflected in an increased activity of other muscles involved in shoulder movements. They showed that the m. rhomboid major, the m. rhomboid minor, and the transverse part of the trapezius muscle showed significantly increased activation levels (232, 175, and 201% respectively), while the m. trapezius pars descending was relaxed (Palmerud et al. 1998). This was similarly true for the m. infraspinatus (Palmerud et al. 1995). Clinically, this implies the need for careful monitoring during myofeedback training in order to prevent generating complaints in other upper-extremity regions. From another perspective, the use of different strategies may have been responsible for the relatively large inter-subject variability as was also found by Hermens and Hutten (2002).

One would expect that changes in RRT are reflected in changes in RMS, e.g. a longer duration of relaxation leads directly to lower RMS values in that interval, since RRT is calculated based on RMS. A close look at Figures 4 and 5 shows that indeed RRT and RMS often change in an opposite way, especially when the changes are relatively large, such as between baseline and T1. In other areas of the curves this is less clear. An explanation is that RRT is a highly nonlinear parameter in the sense that it will only be correlated with changes in RMS when the RMS changes around the threshold used for calculation of RRT. Changes in RMS at a much higher level than the threshold of RRT will not affect RRT. It should be noted that these two parameters represent different physiological processes. RMS reflects a global indication of the muscle activation level, whereas RRT reflects the relative time in which the muscle is relaxed. According to the Cinderella hypothesis, it is not the activation level that is related to the development of myalgia, but the amount of relaxation. This obviously requires a different strategy in preventing myalgia.

One methodological comment should be made. The multiple cross-over design used in this study was not a complete design since only three of all six combinations of the order in which the different feedback intervals could be provided were used. Inherently, this raises the question whether comparison between and within intervals as performed in this study is justifiable and methodologically correct. Visual inspection of the results however, learned that the three separate groups showed close to identical learning patterns over the 3 days, thereby justifying the use of only three out of six sequence combinations.

In conclusion the results indicate that Cinderella-based myofeedback is best provided with the 10-s interval schedule instead of the 5- or 20-s schedules in learning muscular relaxation during a gross-motor task. The 10-s interval schedule showed clinically relevant increases in muscular relaxation as well as reduced muscular activation levels during the feedback training. For each interval, however, the effect of the training did not last when feedback was removed. Based on these findings, it is recommended to investigate the effects of long-duration exposure to feedback training in a larger subject sample.

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