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ARM VERSUS LEG STRESSED DIFFERENTIATED RATINGS OF PERCEIVED EXERTION.

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Abstract.

Although Borg's RPE scale is a universally accepted assessment of an individual's subjective rating of the physical demands of the task on hand, the differentiated scale does not appear to have been put to much practical use in working situations, particularly manual materials handling tasks. The object of this project was to demonstrate the importance of differentiated RPE scores. A homogeneous sample of well conditioned male marathon runners participated in two contrasting working conditions: one of which the emphasis was on the lower limbs (treadmill running); the other being a predominately upper limb activity (arm cranking ergometer). Subjects were required to work for 20 minutes with heart rate and differentiated RPE scores collected every 2 minutes. The same working heart rate was recorded in both sessions and yet there were significant increases in all RPE ratings in the arm cranking condition. It is evident that although the cardiovascular output was similar in both conditions the subjects perceived the unfamiliar arm cranking task to be more demanding. While recognising the value of the use of RPE scores in assessing the worker's perception of the demands of working tasks to maximise the benefits of its use in acquiring the total perception of the work demands, the results of this study would strongly indicate the use of local, central and overall ratings of perceived demands.

Introduction.

While the study of human performance and perceived exertion during physical activity has, in recent years, been the focus of growing attention, the applicability of psychophysical scales in the working environment has still to be fully appreciated. Although detailed metabolic costs of various working situations are often calculated, an individual labourer perceives the work load to be. In 1973 Morgan proposed that the continuation of work, as well as the intensity at which one elects to work, is dependent to a great extent on the individual's perception of the demand of the task.

A subjective personal evaluation of the task is based on perceptual information which involves the inter-

active configuration or processing of numerous input parameters. These include the central cardiovascular and respiratory functions, the peripheral working muscles and joints, as well as the central and peripheral neural systems. Accepting that all of the above input parameters do impinge on an individual's rating of perceived exertion, it can readily be appreciated that any psychophysical judgement is in essence the integration of the demands, "perceived exertion", is based upon a psychophysiological process which is technologically inaccessible, but is readily available in terms of personal awareness and is therefore reportable. Hence a psychophysical evaluation represents a tangible measure of cognitively integrated sensations and should be viewed as a Gestalt rating of perceived exertion (Morgan, 1981; Borg, 1982). Perceived exertion can best

be defined as one's subjective rating of the intensity of the work being performed (Morgan, 1973) or, as Carton and Rhodes (1985) reported, it is a subjective self-report of the energy expenditure using a specific scale for quantification.

Borg (1970) originally proposed that for prolonged work perceived exertion is most forcibly influenced by the adaptation of the circulatory system, thus stressing the role of the cardiovascular system. However, expanding on the original concept, Ekblom and Goldbarg (1971) proposed a two-factor model. They suggested that local influences such as sensations of strain in the working muscles and joints, together with central influences involving the cardiopulmonary system, both contribute to the perception of exertion. Pandolf (1978) also acknowledged that the dominance of either local or central factors in the subjective estimation of exertion appears in part to be related to the amount of active muscle employed by the particular type of work. Clearly work intensity, duration and environmental situation (external factors), together with age, sex, body composition, amount of muscle mass involvement, and general physical condition of the individual, may alter the interplay of the two factors. However, recent research by Mihevic (1981), Pandolf (1982), and Robertson (1982) has indicated strong support for the influence of local factors. These authors cite increasing evidence that central factors do not play as important a role in the perceptions of exertion as was originally thought. Pandolf (1978; 1982) proposed an experimental model for studying local and central factors. This model suggests that undifferentiated ratings from Borg's category scale belong to a "superordinate" level, and that this integrative factor is not necessarily closely linked to the underlying physiological substrata. "Subordinate" or differentiated (local and central) ratings are, however, more closely related to discrete physiological sensations. This model allows for comparisons between local, central and overall ratings of perceived exertion. There is, therefore, increasing support for the use of dif-

ferentiated ratings. Nevertheless as recently as 1990, Genaidy and co-workers, while recognising the need to have some tangible psychophysical assessment of the demands of manual materials handling tasks, failed to identify the importance of differentiated ratings.

Having acknowledged the critical role of differentiated ratings in the assessment of subjective perceptions of the work load, the present investigation therefore examined the interplay between these factors in two contrasting situations. In the first of these, emphasis was placed on the activity of the lower limbs, while in the second the physical demand was primarily on the upper limbs.

Method

Eight well conditioned Caucasian males (all competitive marathon runners whose development emphasised leg strength rather than arm strength) volunteered to participate in the study. They were required to attend three separate testing sessions. As the main objective of this project was to identify the importance of differentiated ratings of RPE, it was deemed essential to establish the same working heart rate for both conditions, thus standardising the physiological variable so commonly used to assess work output. Heart rate was recorded by means of a Cardionics Cardiometer. Elasticised conductive strips were attached to the Cardiometer lead and placed around the chest of the subject at the level of the xiphoid process.

The first testing session was used to collect basic demographic data as well as to assess a 'steady state' working heart rate of the subject when running on the treadmill and when arm cranking on the cycle ergometer. During this first session the general principles of the perceived exertion scale were explained to the subjects, who were also given very explicit instructions on the use of differentiated ratings for local, central and overall RPE.

The protocol for data collection under the two working conditions was very similar, with the only difference be-

	Heart Rate b.min-1	Ratings of Perceived Exertion		
		Local	Central	Overall
condition 1 (treadmill)	156 (9.3)	11.07 (0.41)	10.86 (0.68)	10.89 (0.93)
condition 2 (arm cranking)	154 (7.1)	15.84* (0.75)	13.31* (0.91)	14.32* (1.16)

*=Significant condition differences (p< 0.05).

TABLE 1. Heart rate and differentiated RPE responses under two contrasting conditions.

ing the actual physical activity required of the subjects. The main criterion was to replicate the same working heart rate during both conditions.

Condition 1; (lower limbs).

The subjects were required to run for twenty minutes on the treadmill. In an attempt to emphasise the demands made on the legs the treadmill was set at an incline, set at 4 percent gradient for the first 10 minutes and at 7.5 percent gradient for the final 10 minutes. The speed of the treadmill was occasionally adjusted in order to retain a constant cardiovascular response.

Condition 2; (upper limbs).

The subjects were required to armcrank the pedals of the ergometer for 20 minutes. They were instructed to pedal in time to a metronome set at 60 r.p.m. against a set resistance for the first 10 minutes and then reduced to 50 r.p.m. for the final 10 minutes, with the resistance increased. Although the appropriate resistance required to achieved a similar heart rate recorded in condition 1 had been established at the first testing session, minor adjustments were made when necessary, in order to retain the pre-set working heart rate.

Every 2 minutes under each condition the subjects were presented with a plastic card illustrating the Borg (1970) RPE scale, and were required to give 3 ratings. The first was a local rating (for legs under condition 1, and for arms in condition 2); the second was a central rating and finally a third overall rating of their perception of the physical demands being imposed on them.

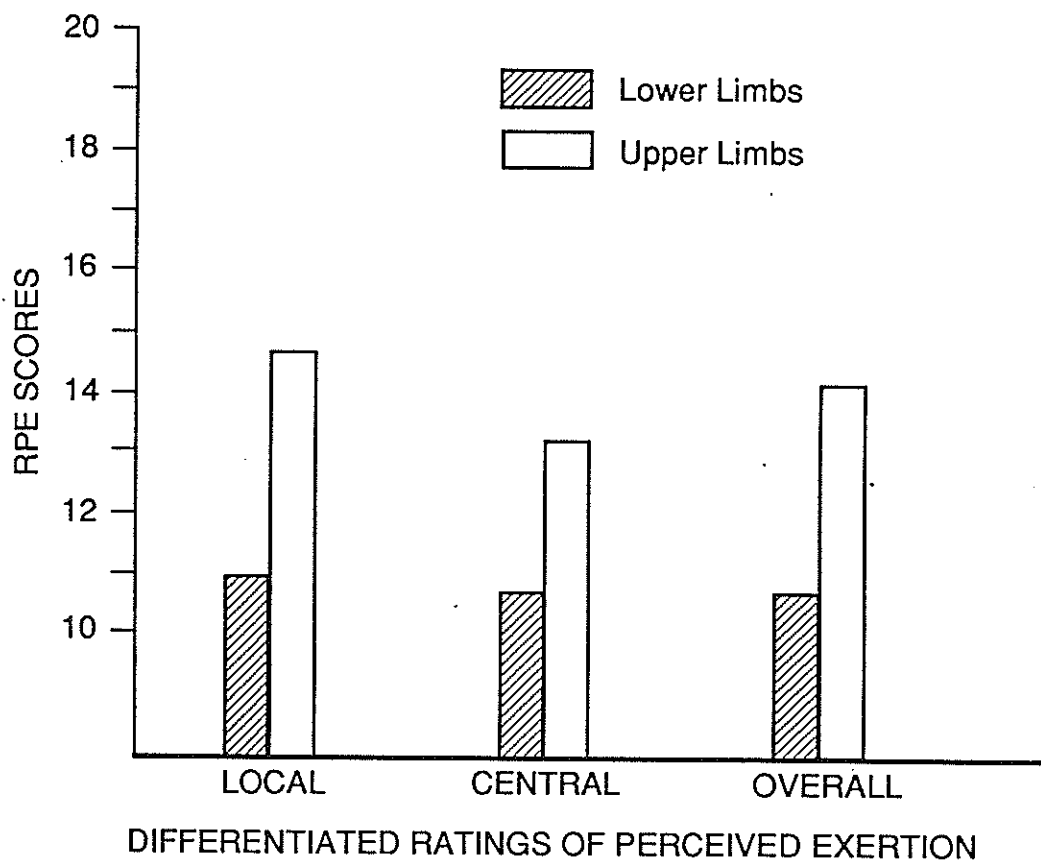
At the same time as the RPE ratings were recorded, the working heart rate was noted.

Results.

The basic physical characteristics of the subjects were; mean age 24.6 years; mean stature 176.5 cm and mean mass 69.3 kg. Related student's tests revealed that there was no significant difference in the working heart rates recorded under both testing conditions, with the mean heart rate for Condition 1, (treadmill) being 156 b.min and for Condition 2, (arm cranking) being 154 b.min. There were, however, significant differences in all RPE ratings as illustrated in Table 1 and Figure 1.

Discussion.

Several studies have suggested a strong link between heart rate and



RPE SCORES

FIGURE 1. Differentiated Ratings of Perceived Exertion under a lower limb dominated activity, and a predominately upper arm activity.

perceived exertion (Borg, 1970; 1982; Pandolf, 1978; Carton & Rhodes, 1985). However, while Carton and Rhodes (1985) report that heart rate and RPE are probably indirectly related through their common dependence on physical strain, it is clearly evident that if the 'Gestalt' response emphasised by Borg (1970) is accepted, then cognizance must be taken of 'other' impinging factors. These factors, such as the type of work (Pandolf, 1978); strain on the local musculature (Noble et al. 1973) and haemodynamic mechanisms (Robertson, 1982), may well be operating as a basis for perceptual differences, in seemingly similar cardiovascularly demanding situations.

In an attempt to magnify the effect of auxiliary factors on the ratings of an individual's perception of the physical demands of a working situation, every attempt was made to elicit the same physiological response, as measured by the working heart rate, in the two distinctly different work demands. It is evident from the results that this was achieved. It is thus highly unlikely that any observed differences in the perceived exertion ratings were specifically mediated by heart rate. Clearly there must have been other factor(s) influencing the subjective report of exertion, even in the case of the central ratings. For although there were no differences in the working heart rates for the two conditions, the central ratings were significantly higher under the arm cranking condition (x central rating: legs, 11; arms 13). It may therefore be concluded that, while the heart rate responses were similar, the well-conditioned marathon runners perceived themselves to be under greater cardiovascular stress in the predominantly upper limb activity.

A similar trend of responses, though more pronounced, was recorded in the local ratings of perceived exertion where the rating in the predominantly lower limb activity on the treadmill (11) was significantly less than the perception of arm strain in the arm cranking condition (16). This was no doubt due to the subjects all being competitive marathon runners whose

extensive training programmes promoted specific aerobic adaptations within the working muscles of the legs. Although recorded working heart rates were the same, all subjects clearly experienced the less familiar task of arm cranking as substantially more physically demanding.

In 1978 Pandolf proposed that when a particular factor or psychological cue becomes accentuated by either an elevated rate, concentration or value, it is likely to dominate the overall rating of perceived exertion. The results of the present study fully support this notion in that there was a concomitant elevation in the overall RPE which increased from 11 under Condition 1(legs) to 14 in Condition 2 (arms). It was evident that the strain experienced in the arm cranking task exerted a greater influence over the final rating.

In conclusion, while acknowledging that central factors may act as amplifiers that potentiate the local signals in proportion to the aerobic metabolic demand (Robertson, 1982), cognizance must be taken of the findings of Pandolf (1982), and Nobel and Allen (1984), who emphasise that local components provide the most intense sensory stimulus and may well dominate the overall effort sensation. Therefore, as RPE becomes a more widely used tool to evaluate the physical demands of various types of work, particularly in manual materials handling tasks, the use of differentiated ratings becomes increasingly important for meaningful psychophysical analyses.

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