CLINICAL RESEARCH

Pain perception in competitive swimmers

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Abstract

The pain perception of 30 competitive swimmers was studied using experimentally induced ischaemic pain. The pain thresholds and tolerances of this group were compared with those of 30 club swimmers and 26 non-competitive athletes. While pain thresholds showed little difference between the groups, pain tolerances were considerably different. Pain tolerances of the competitive swimmers varied according to the stage of the training season. The relation between ischaemic pain and that experienced during swimming training was studied using a pain questionnaire composed of several systematically structured verbal categories. Both types of pain were classified along similar dimensions, and it was concluded that the experimentally demonstrated pain tolerances could be generalised to the normal pain perception of the subjects.

The origins of the enhanced pain tolerances of the competitive swimmers would seem to lie in their systematic exposure to brief periods of intense pain. These data could have relevance for the treatment of chronic pain in certain diseases.

Introduction

Over the last few years there has been a considerable increase in research into the psychological and physiological basis of pain.[1 2] Certain categories of chronic pain sufferers have benefited considerably from treatments based on such research.[3] There still exists, however, a large population of sufferers from chronic or episodic pain whose condition is best treated by moderate but sustained levels of chemical analgesics. Such long-term use of analgesics gives cause for concern to both physician and patient, and it would be useful for the optimal management of chronic pain if the psychological factors that control the threshold and tolerance levels of extended pain were understood in greater detail.

Although there are practical and ethical problems in studying systematically the characteristics of pain perception there is a population of chronic pain sufferers whose pain perception is not complicated by the presence of any disease process—namely, competitive athletes in training. Observations of everyday experiences in sport indicate that the ability to withstand high levels of pain is an important quality for an athlete if he is to excel in his activity. Normally the most striking feature of extended pain is its tendency to take control of the organism's whole behaviour, and even a weak pain stimulus tends to dominate over all other stimuli. Nevertheless, athletes continue to perform with sprained joints, pulled and contused muscles, and cuts in sensitive tissue, even when all-out exertion is demanded. It is in fact difficult for an athlete to avoid pain even though this sensation is normally so influential over behaviour, and the willingness of an athlete to tolerate high levels of pain is essential for success in top competition. Coaches of athletes have long been aware of considerable variability in the pain tolerances of trained athletes, but the psychophysiological factors that produce this variability are not well understood. A swimming coach, for example, can only rely on his experience to tell him whether he is training a swimmer too hard or if a swimmer has reached his peak both physically and in his pain tolerance.

The purpose of our study was to investigate the athletes' ability to tolerate pain during extreme physical stress. The study sought to provide information on the nature of pain perception in competitive swimmers both in terms of their responses to controlled induced pain and also by a detailed subjective specification of the pain experienced during swimming. Knowing more about such swimmers' response to pain could enable more specific predictions to be made regarding a swimmer's ability to push himself through the pain barrier. An understanding of the psychological factors that control the willingness of athletes to withstand pain would also be relevant in defining the extent to which people with chronic pain associated with a disease process could be reasonably encouraged in the acceptance of their pain.

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Subjects and methods

Three groups of subjects were used in the study. The first group consisted of 30 highly conditioned swimmers of the Scottish national

squad (16 men, 14 women). The second group comprised 30 club swimmers (13 men, 17 women) whose experience of competition was only at club level. The third group was made up of 26 non-competitive athletes (10 men, 16 women), volunteer first-year undergraduates attending the University of Stirling, of whom none had had experience of sport at a competitive level. The national squad was tested twice in one training season, in March and in June, at the peak of their training, and then a third time in the following October, at the beginning of the next training season.

Threshold and tolerance levels for experimentally induced pain were established using a version of the conventional ischaemic pain test.[4] This test was chosen because of the possible similarity in pain perceived during induced ischaemia and that experienced by competitive swimmers undergoing high work loads during training. The arm of a subject was fixed at 90° with the hand held upwards and the elbow supported by a table. A standard sphygmomanometer cuff was wrapped around the upper arm and inflated to 100 mm Hg above systolic. Ischaemia was induced by having the subject open and close the hand into a fist at the rate of one fist contraction per second. A metronome helped to establish a regular rhythm. Pain threshold was recorded in terms of the number of fist contractions that produced a report of a sensation recognisable as pain and not merely discomfort. Pain tolerance was recorded in terms of the maximum number of times the subject was willing to contract his fist under the ischaemic conditions. A fatigue score was also recorded; this corresponded to the point at which the subject could not complete full finger extension after contracting the fist. Normal grip strength of the subjects was also measured using a hand dynamometer.

A pain perception questionnaire adapted from the McGill Pain Questionnaire[5] was administered to the three groups of subjects. This questionnaire consists of 20 categories or groups of words that can be used to give a detailed description of a pain. The words have been classified as belonging to three major descriptive classes: sensory, affective, and evaluative. The words in a given category are also ranked according to their position on a five-point scale assigned on the basis of agreement between a number of different population groups.[6] In the present study we did not need to use more than the basic 16 groups of words that were originally used by Melzack and Torgerson[6] in their scaling procedures. The use of the pain questionnaire made it possible to determine whether ischaemic pain was categorised by a distinctive set of verbal descriptions by the three groups of subjects. Moreover, it was possible to determine whether competitive swimmers found any similarity between the ischaemic pain and pain experienced as a result of severe muscle exercise during training. The swimmers were asked to choose words which they associated with swimming in general as well as with each specific component of a training session. The spatial distribution of the pain and overall intensity of the pain during swimming were also assessed systematically.

Kruskal-Wallis analysis of variance by ranks was used to evaluate differences in threshold and tolerance for the three groups of subjects. A Wilcoxon test for correlated samples was used to compare the tolerance scores of the national squad obtained at different stages in training. Two-tail tests of significance were used.

Results

PAIN PERCEPTION

The results from the questionnaire produced a distinctive group of words to describe the pain experienced during the muscle ischaemic test, and all three groups showed a high degree of agreement on these descriptive classifications. Five out of the original 16 word categories had more than two-thirds of each subject group choosing words from them. A criterion of two-thirds support was used in the original classification of the word groups.[6] The chosen categories were: "temporal," "constrictive pressure," "dullness," "tension," and "evaluative." The component words of these categories are shown in table I. There was disagreement over only one category. The national squad showed a preference for the word "tingling" to describe ischaemic pain, which was not included in the above five categories. The descriptions chosen by the national and club swimmers to specify pain experience during swimming also showed a high degree of agreement between the two groups. In addition, using the criterion of two-thirds support from the subjects, swimming pain was characterised by the same five verbal categories out of the 16 available. There was disagreement over only one category: the national swimmers tended to use a "punishment" category more frequently than the club swimmers. These data support the belief that the perceptual experience of the pain induced experimentally in this study was of a similar quality to the pain experienced during swimming training and that the three different subject groups were similar in their overall perceptual responses to the pain-inducing conditions.

TABLE I—*Verbal categories of pain questionnaire receiving at least two-thirds support from the subject groups to describe ischaemic and swimming pain*

Class	Category	Descriptions: Ischaemia	Descriptions: Swimming
Sensory	Temporal	Pulsing	
		Throbbing	Throbbing
	Constrictive pressure	Tight	
		Pressing	Pressing
		Squeezing	
		Gripping	
		Cramping	Cramping
	Dullness	Sore	Sore
		Numbing	
			Hurting
		Aching	Aching
		Heavy	Heavy
Affective	Tension	Tiring	Tiring
		Fatiguing	Fatiguing
			Exhausting
Evaluative	Evaluative	Annoying	
		Distrracting	
		Troublesome	
		Discomforting	
		Distressing	
		Intense	Intense

PAIN THRESHOLD AND TOLERANCES

Threshold scores, in terms of the number of fist contractions achieved before pain was reported, are shown in table II. Threshold scores for the national squad swimmers, the club swimmers, and non-competitive athletes were not significantly different. In addition there were no significant differences between the threshold scores of men and women.

Tolerance scores, in terms of maximum number of fist contractions achieved under conditions of ischaemia, are shown in table III. The national squad showed highly significant differences in pain tolerance from the other two groups, and the club swimmers showed significant differences from the non-competitive athletes at the 0·05 level. Men and women in each group did not differ significantly in tolerance scores except among the club swimmers, where the men showed slightly higher tolerance scores, but differing only at the 0·05 level of significance. In addition, among the national swimmers there was no significant relation between tolerance scores and grip strength as measured by the hand dynamometer. The tolerance scores of the national swimmers referred to in table III were measured in March. Tolerance scores of the same subjects were measured in June, at the

TABLE II—*Pain threshold scores (number of fist contractions) for national swimmers, club swimmers, and non-competitive athletes. Scores are means ± SD*

	National swimmers (A)	Club swimmers (B)	Non-competitive athletes (C)
No of swimmers	30	30	26
Score	52·0 ± 23·1	41·6 ± 9·8	46·7 ± 14·5

χ^2 tests: A *v* B: 2·2 (NS); A *v* C: 0·36 (NS); B *v* C: 1·2 (NS).

TABLE III—*Pain tolerance scores (number of fist contractions) for national swimmers, club swimmers, and non-competitive athletes. Scores are means ± SD*

	National swimmers (A)	Club swimmers (B)	Non-competitive athletes (C)
No of swimmers	30	30	26
Score	131·7 ± 44·4	89·2 ± 37·0	70·1 ± 22·9

χ^2 tests: A *v* B: 16·8 ($p < 0·0001$); A *v* C: 27·7 ($p < 0·0001$); B *v* C: 5·0 ($p < 0·05$).

peak of the training season, and then in October, after the summer break in major competitive swimming, when the training sessions were again at their initial low work-load levels. Significant changes in tolerance scores were seen (table IV), highest tolerances occurring at the peak of training, and then dropping again to a comparatively low level at the start of the new training season.

TABLE IV—*Tolerance scores of the national swimmers at selected stages of the training season. Scores are means ± SD*

	March	June	October
No of swimmers	30	30	30
Score	131·7 ± 44·4	198·3 ± 72·9	116·7 ± 31·6

March *v* June: $p < 0.001$; March *v* October: $p < 0.001$; June *v* October: $p < 0.001$.

Discussion

High tolerances of ischaemic pain in competitive athletes have been shown in at least one previous study.[7] Studies such as this have, however, left open the question of how far the characteristics of experimental pain perception can be generalised from the specific experimental circumstances. Athletes may appear to tolerate noxious sensory stimuli of high intensity, but such stimuli are often completely ignored in the height of competition. Diminished consciousness of pain is not tolerance in its proper sense, nor would be a general insensitivity to sensory stimuli over a wide range of intensity values. Our data, however, indicate that the high tolerance of ischaemic pain shown by competitive swimmers reflects a genuine and general pain tolerance. The national squad swimmers did not appear to be simply insensitive to painful stimuli, since there were no significant differences in pain thresholds between them and the other subject groups. Furthermore, the choices made of the verbal categories from the pain questionnaire showed that both the experimental and swimming pain were classified along similar sensory, affective, and evaluative dimensions. Therefore there is good reason to believe that the tolerance levels shown under the conditions of ischaemic pain reflected those normally found in the subjects under study. This conclusion is supported by the fact that the national squad swimmers reported that the pain experienced during swimming was the worst that they had ever experienced and chose words from the questionnaire that had high-intensity scale ratings. In comparison the club swimmers rated ischaemic pain as being higher than that normally experienced during training.

What then could be the reasons for the superior pain tolerance in the competitive swimmers? Possibly the high tolerance could reflect in some way the superior muscular competence of trained athletes. There was, however, no correlation of grip strength with tolerance among the swimmers, nor were muscle-fatigue levels, as indicated by an inability to fully close the fist under the ischaemic conditions, related in a simple way to pain-tolerance scores. Muscle fatigue provided an ultimate ceiling for the number of possible fist contractions that could be achieved under ischaemic conditions, but though the national swimmers showed more signs of muscle fatigue in the ischaemic test (23 out of 30), few of the other subjects showed any such fatigue (7 out of 56). It is unlikely therefore that some form of muscle fatigue or inadequacy was limiting the pain-tolerance scores of the club swimmers or the non-competitive athletes.

The generally superior pain tolerances of the highly trained swimmers could reflect the action of complex experiential and motivational factors rather than any simple physiological mechanism. The national swimmers had had considerable experience of extended bouts of pain during training. Such experience could be expected to modify considerably the apprehension normally associated with high levels of pain. In addition, not only is there considerable pressure for such swimmers from peers and coaches to tolerate high levels of pain, but also high levels of pain are often treated by swimmers as confirmation of the adequacy of their training work load and seriousness of effort. It is reported that pain can be strangely satisfying to the highly motivated athlete.[8]

The changes in pain tolerance of the swimmers during the training season indicates that some form of short-term adaptation to pain can also occur as a result of systematic exposure to periods of intense but limited pain. The characteristics of this adaptation indicate the possible role of neurohormonal mechanisms such as those of the endogenous opiate system.[9,10] In addition, there is evidence, in the rat at least, for the existence of a non-opiate-related analgesic state that is stress related and conditionable.[11] Such a form of analgesia might well have a role in the conditioning of pain tolerance in the systematically stressed athlete.

Finally, if these data on pain perception in the trained athlete have any relevance for the patient suffering chronic pain due to a disease, they do suggest that if such pain cannot be eliminated entirely or consistently then some tolerance to the pain might be developed by systematic limited exposure to it. In addition, the data of the present study confirm the commonly held belief that considerable changes in pain tolerance can occur depending on the importance put on such pain by both the sufferer and those associated with him.

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PEOPLE ought to be extremely cautious leſt they take other eruptions for the itch; as the ſtoppage of theſe may be attended with fatal conſequences. Many of the eruptive diſorders to which children are liable, have a near reſemblance to this diſeaſe; and I have often known infants killed by being rubbed with greaſy ointments that made theſe eruptions ſtrike ſuddenly in, which Nature had thrown out to preſerve the patient's life, or prevent ſome other malady.

MUCH miſchief is likewiſe done by the uſe of mercury in this diſeaſe. Some perſons are ſo fool-hardy as to waſh the parts affected with a ſtrong ſolution of the corroſive ſublimate. Others uſe the mercurial ointment, without taking the leaſt care either to avoid cold, keep the body open, or obſerve a proper regimen. The conſequences of ſuch conduct may be eaſily gueſſed. I have known even the mercurial girdles produce tragical effects, and would adviſe every perſon, as he values his health, to beware how he uſes them. Mercury ought never to be uſed as a medicine without the greateſt care. Ignorant people look upon theſe girdles as a kind of charm, without conſidering that the mercury enters the body.

(Buchan's *Domeſtic Medicine*, 1786.)