

A PROPOSED METHOD FOR ESTIMATING THE EFFICIENCY AND EFFECTIVENESS OF TECHNIQUES OF MUSCULOSKELETAL THERAPY

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This paper proposes a numerical method for comparing the results of trials of musculoskeletal therapy as an alternative to ranking literature by experts in the field. The method is based on the observation that the course of recovery of patients with musculoskeletal complaints can be approximated by an exponential function.

It is estimated that 30 techniques of manipulation are currently taught in chiropractic colleges.¹ However, little published data are available that documents the effectiveness of a specific technique.² This lack of information severely limits the ability of patients to choose the best means of addressing their musculoskeletal problems, casts doubt on the choices of technique that are selected to be taught in programs of formal instruction, clouds the ability of third party payers to most effectively allocate resources to the treatment of their members, and limits the ability of individual practitioners to make informed decisions regarding optimum care for their patients. In order for any of these parties to make reasonable judgments regarding the use of specific manipulative therapies, questions such as the following need to be addressed: (1) Are specific techniques more effective than others in general? (2) Are specific techniques more effective than others for specific categories of musculoskeletal complaints? (3) Given a specific musculoskeletal symptom, when in the course of treatment should the clinician and patient reasonably expect to achieve improvement?

The literature relating to these and similar questions is sparse and complicated by the fact that chiropractors, physical therapists, and osteopaths use multiple techniques. These techniques are often lumped under one general category as if all techniques within a discipline were

equivalent and that any combination of techniques were equivalent to any other combination of techniques selected by the practitioners involved in any particular study.²⁻⁴ Despite these problems, progress is being made in the effort to develop better understanding of the effectiveness of techniques of musculoskeletal therapy and of methodology for evaluating the effectiveness of these techniques and of comparing the results of effectiveness studies. Gatterman et al⁵ used the methodology of expert review to rate the literature of chiropractic technique effectiveness and went further using the same technique to rank specific technique effectiveness in terms of the personal experience of a panel of expert practitioners. It was noted by Gatterman et al that the ratings of the panel of experts were influenced by the rater's individual training and experience with the techniques that were the subject of the rating. That is, the raters who had been taught a specific technique or who used the technique in their clinical practice showed a marked tendency to rate those techniques as being more effective than techniques that they did not use and had not been taught.

This paper introduces a numerically based methodology for comparing studies of the effectiveness of musculoskeletal therapy that attempts to eliminate the bias of education and familiarity inherent in the use of more subjective rating methodology. The methodology is based upon the observation that patient response to therapy may be approximated by an exponential function and uses a single metric, the half-life of the response of patients to the therapy (the time for half the patients in the study to recover) as a measure of overall goodness. This measure may be further divided into a measure of the efficiency (the rate at which patients respond to the therapy) and the proportion of patients responding to therapy in the long run (a measure of effectiveness).

PROPOSED MODEL

The author proposes that survival analysis be used as a method for the evaluation of the results of clinical trials of

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J Manipulative Physiol Ther 2005;28:206-210.
Paper submitted May 21, 2003.
0161-4754/2005/\$30.00
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doi:10.1016/j.jmpt.2005.02.008

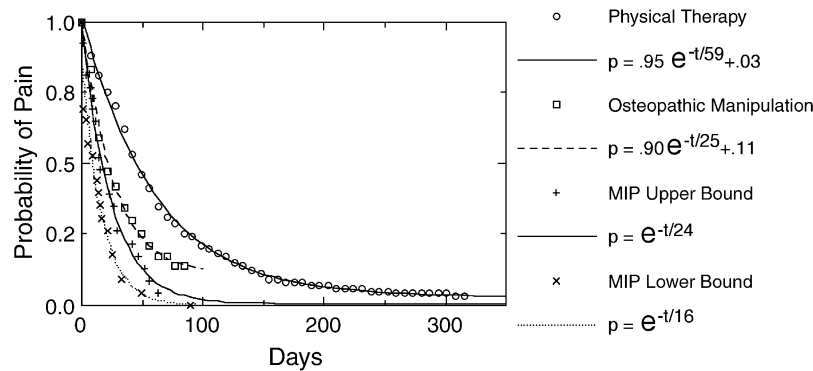


Fig 1. Example of overestimation of effectiveness. Osteopathic manipulation evidences an almost identical response rate as the upper bound of multiple impulse treatment but would be judged to be less effective because approximately 90% of the patients treated with osteopathic manipulation responded “in the long run” whereas 100% of the patients treated with multiple impulse therapy responded to the therapy.

musculoskeletal therapy. Observing that the results of studies of the course of patient response to musculoskeletal therapy often followed what appeared to be an exponential function, the author extended survival analysis by fitting the results to an exponential function of the form

$$P = Ce^{-kt} + b$$

where P equals the probability of pain; C , k , and b are constants that determine the fit of the experimental data; e equals the base of natural logarithms (approximately 2.71828); and t is time.

Because the probability of pain is 1 at time 0 (all patients start out in a state of pain), we have the relationship $C+b=1$, which results from the fact that the long-term probability of pain is b , because as t approaches infinity, Ce^{-kt} approaches 0. The constant b represents the fraction of patients who will not respond to the therapy regardless of how long it is applied. Ideal therapies would exhibit a b value of 0 (every patient would respond to the therapy). The constant k is a measure of the rate at which patients respond to the therapy. The larger the value of k , the faster the patients respond to the therapy and the faster the probability of pain drops. Taken together, C , b , and k can be used to predict the time at which one half of the patients will be pain free. The half-life of patient response is proposed as a measure for comparison of musculoskeletal therapies.

Although the above methodology is appropriate for comparing the results of studies that use survival analysis, the comparison of studies using the visual analogue scale (VAS) and parametric statistical methods such as analysis of variance is problematic because the results of these studies are routinely presented as 3, or more commonly, 2 points in time: pain intensity scores obtained before treatment and pain intensity scores obtained after treatment. However, assuming that the response of patients as reflected in studies that use the VAS as an indicator of

Table 1. Application of proposed model comparing 4 techniques of musculoskeletal therapy for low back pain using metrics derived from survival analysis

Technique	Half-life (d)	Efficiency (d)	Effectiveness (%)
Physical therapy	44	59	95
No (manipulative) treatment	24	33	97
Osteopathy	21	25	90
Multiple impulse therapy	9-16	16-24	100

response to therapy will be similar in form to the response of patients observed in studies using survival analysis, it is instructive to extend this method of comparison to the former type of study.

If a study only reports 2 or 3 points on the patient response curve, the full exponential model cannot be fit because information about the long-term response is not available. However, if the assumption is made that eventually all patients will respond to the therapy and reach the “pain-free” state ($b=0$), then the rate constant k can be calculated using the simplified model $P=Ce^{-kt}$. This further assumes that VAS results are in some sense linear (the distance between 8 and 7 on the VAS is similar to the distance between 4 and 3) and that patient response as reflected in VAS scores follows an exponential function as suggested by survival studies.

The assumption that the constant b is set to 0 reduces the power of the comparison methodology because only the rate of response is used as the basis for the comparison. This means that 2 methods of treatment with the same rate of response would be assumed to be equal in effectiveness even though one may only be effective for 80% of patients whereas the other is effective for all

Table 2. Estimated half-life for response to musculoskeletal therapy of 5 studies using VAS and analysis of variance

Technique	Complaint	Study	Number in study	Estimated half-life
Diversified	LBP	Hsieh et al ⁴	50	42
Myofascial	LBP		50	39
Diversified with myofascial	LBP		50	24
Back school	LBP		50	22
Activator	Neck pain	Wood et al ⁹	15	25
Diversified	Neck pain		15	28
High velocity, low amplitude	LBP	Triano et al ¹⁰	47	18
High velocity, low force	LBP		39	36
Back education program	LBP		43	23
Diversified without modalities	LBP	Hurwitz et al ¹¹	169	83
Diversified with modalities	LBP		172	52
Thoracic manipulation	Thoracic pain	Schiller ¹²	15	24
Nonfunctional ultrasound	Thoracic pain		15	64

LBP indicates low back pain.

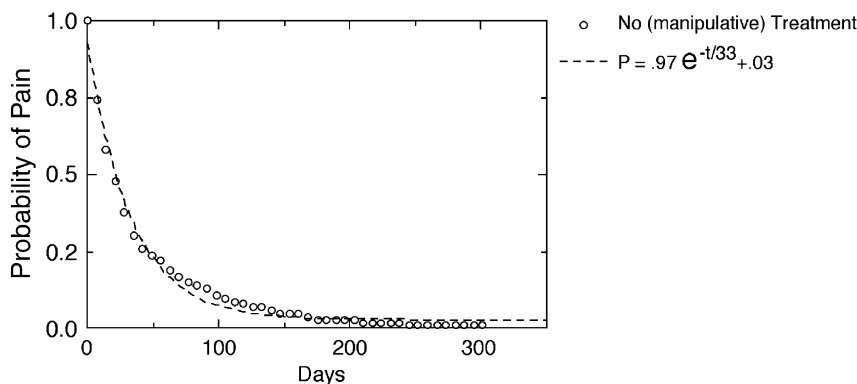


Fig 2. Recovery from low back pain without manipulative treatment.

patients. An example of this overestimation of effectiveness is shown in Fig 1.

APPLICATION OF MODEL

Table 1 shows the results of the comparison of physical therapy, osteopathy, no (manipulative) treatment, and multiple impulse therapy using the half-life, efficiency, and effectiveness metrics derived from 3 different studies that used survival analysis. The physical therapy and no treatment data were replotted from van den Hoogen et al.⁶ The osteopathic data were recalculated from MacDonald and Bell.⁷ The multiple impulse data were taken from a study performed by Evans et al.⁸ The half-life shown for each technique is a reliable indicator of overall goodness. The effectiveness metric shows all 4 techniques to be nearly equal in effectiveness over the long run. The major difference in the techniques is in their efficiency, physical therapy being the least efficient and multiple impulse therapy being the most efficient technique.

Using the simple exponential model as an approximation and assuming that the constant *b* is equal to 0, the half-life for studies reporting only 2 or 3 points on the VAS may be estimated from the difference between the initial pain scale readings and the pain scale readings after the passage of a known time. The results of 5 recent studies^{4,9-12} serve as examples. The studies were selected because their objective was to compare several techniques of treating musculoskeletal symptoms and they use a subjective pain scale as a criterion. The results of comparison by technique and study are presented in Table 2. Only the Schiller study¹² found a statistically significant difference between the methods under study. These comparisons assume that the constant *b* in the exponential model is equal to 0 indicating that all patients in the study will reach a pain-free state. This may be optimistic as some studies show that up to 20% of patients do not respond to specific techniques of musculoskeletal therapy.^{3,6,13-15}

The results are shown in Table 2. Rather than ranking the techniques as was done in the Gatterman study, the calculated half-lives for each study are tabulated. The

tabulation indicates that the similarity of patient response to therapy within each study is high, and aside from multiple impulse therapy, the similarity of the half-lives between each study is greater than the difference. For comparison with studies using survival analysis, refer to [Table 1](#).

The technique comparison using the method of approximation of patient response with an exponential function provides a powerful means of estimating the efficiency as well as the effectiveness of specific techniques of musculoskeletal therapy. The methodology is especially well suited to the comparison of the results of studies that use survival analysis but may also be used to compare the efficiency of studies using the VAS and parametric statistics. In both instances, the inherent bias of training and familiarity associated with comparisons of expert panels is avoided.

The similarity of the responses within each study in [Table 2](#) across this apparently diverse set of techniques raises questions. Is it reasonable that 2 techniques, such as one being a single impulse delivered by a low energy spring-loaded actuator and the other being the forceful rotation of the head and neck accompanied by an audible cavitation of fluid within the joints, have equal results?⁹ Is it reasonable that similar techniques are no more efficient than “back school” as in Hsieh et al?⁴ Is the anecdotal evidence of clinicians who claim that “all techniques are equally effective” simply being confirmed by these studies, or is there some common underlying process that might better explain these results? Although definitive answers to these questions are beyond the scope of this study, examination of [Fig 2](#) suggests that the process of natural healing or “spontaneous remission” of low back pain may be more effective than generally appreciated. The data represented in [Fig 2](#) are replotted from van den Hoogen et al⁶ and represents Kaplan-Meier analyses of patients seeking care for low back pain in the clinics of general practitioners in the Netherlands. The points represent the response of patients who received no specific manipulative treatment of low back pain. The half-life of response for the patients receiving no treatment is 24 days.

The half-life of the “no treatment” is similar to the half-life of patient response in many studies of the effectiveness of treatments for musculoskeletal conditions. This suggests that a major component of the results of these studies may in fact be due to the underlying effect of the natural healing process. This would explain the apparent equivalence of disparate techniques. Close examination of the rate of change of the data in [Fig 1](#) suggests that early in the course of treatment, it may be impossible to differentiate the effects of any therapy from any other therapy or from the effects of the natural response of the musculoskeletal system. It is hypothesized that differences in therapy will likely be observed only after most patients in the study have recovered from their incidence of back pain. That is, differences in patient response rate due to the influence of different therapies will not be observed, using easily

achieved patient sample sizes, until the rate of natural healing becomes less than the rate of response of the therapy. There is some support for this hypothesis in the literature.^{10,13,16,17} Alternatively, to reveal differences in therapeutic techniques, the number of patients in studies using the VAS, such as those cited, may have to be greatly increased or other methodologies of analysis such as survival analysis used.

In conclusion, the comparison of techniques of musculoskeletal therapy using a single metric (the half-life of patient response) may be useful when applied to studies using survival analysis where it allows the effectiveness of techniques as well as their efficiency to be estimated. This suggests that studies of many techniques of chiropractic and osteopathic therapy may yield similar half-lives. One possible explanation for this result is that, especially in the early course of patient treatment, the natural healing process dominates the results and therefore differences in treatment techniques and protocols are unlikely to be discerned until most patients have finished the course of treatment. In other words, differences in treatment efficiency and effectiveness are unlikely to be observed using relatively short treatment times and small sample sizes.

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