Abstract

Isokinetic assessment of the muscles of the trunk in chronic low back pain patients

C.F. Roques, A. Felez, S. Gleizes, Th. Van den Bossche, X. de Boissezon and M. Chatain
Service de Médecine Physique, CHU de Toulouse, Toulouse, France

Aims: to assess the strength of the muscles of the trunk and the correlations between the muscular impairment and the symptoms of the patients.

Methodology: 30 CLBP patients (15 male, 15 female; age 42–22–54) were investigated: age, gender, body mass index, pain (VAS, St-Antoine Hospital’s Pain Questionnaire SAHPQ), anxiety (STAI), depression (Beck), RIII nociceptive reflex, fingertip floor distance, lumbar function (Eifel and Dougados indexes). The reduction (%) of Quality of Life (QL) was assessed using the Dallas Pain Questionnaire (groups of items: activities of daily living-ADL-, Professional-W-, Anxiety and Depression-AD-, Social Interactions-IS-). The lumbar muscles’ strength was assessed using an isokinetic dynamometer Cybex 6000. The maximum concentric peak torque of the flexors and of the extensors was measured at 30°, 60° and 120° sec\(^{-1}\); the results were related to the normal values for the gender and the age.

Results: We observed a reduction of the peak torque of the flexors and of the extensors of the trunk; the ratio extensors/flexors had diminished. The impairment of the extensors was always significantly higher than the impairment of the flexors. The peak torque of the flexors was not different at the different speeds. The peak torque of the extensors at 30° sec\(^{-1}\) was significantly different of the peak torque at 60° and 120° sec\(^{-1}\). The women have a significantly increased muscular impairment.

The muscular impairment was not correlated with the different clinical parameters (age, gender, pain, function, mood, lumbar stiffness). We only observed significant correlations between the peak torque of the flexors at 30° sec\(^{-1}\) and the different groups of items of the QL.

Discussion: The impairment of the strength of the muscles of the trunk was evident in these chronic low back pain patients. But we observed a lack of correlations with the main clinical data. A critical approach of the muscular strengthening could be relevant.

Conclusion: the impairment of the muscles of the trunk is poorly correlated with the symptoms of chronic low pain; the impact of the muscular strengthening have to be investigated.
Abstract

Correlation between the isokinetic gain and the quality of life measured by Dallas’ score

H. Carlier, J.-C. Farasse, J.-P. Hible and H. Cany
Service MPR, Clinique Saint Roch, 128 Allée saint Roch, 59400 Cambrai, France

Rehabilitation of backpain has been improved during the last decades especially with the introduction of the recondition to effort and a global rehabilitation. The valuation by isokinetic and the valuation of the backpain’s repercussion in the all-day life are usual, studying their evolution and their correlation seemed interesting to us.

Purpose: The foremost goal is to measure the correlation between the evolution of the muscular strength measured by the isokinetic tests and the progression of the psychosocial repercussion by the Dallas’ auto-questionnaire at the time of recondition to the effort of backpain.

Methodology: It is a retrospective survey of 26 low back pain subjects who benefited from a recondition to effort in daily hospital during 5 weeks, 4 days a week. An isokinetic rating on Cybex Norm including a sequence of 3 repetitions at 30°/s and a sequence of 20 repetitions at 120°/s is made at the beginning and at the end of rehabilitation just as the Dallas’ score. The analysed parameters are the strength peak and the flexor/extensor ratio at 30°/s and 120°/s, the daily activities, the professional activities, the angst and the sociability of Dallas’ score. An analysis of the correlations between isokinetic gain and the improvement of Dallas’ score is made by using Pearson’s coefficient and the significance thresholds assessed by Student’s test applied to small samples and to pattern sequences.

Results: The first number illustrates Pearson’s coefficient, and the second one illustrates the probability threshold. (See Table 1).

Discussion: The only correlations that can be demonstrated are the correlations which were made between the different categories of Dallas’ score and also between the gains of the rachis extensors at two executing speeds.

Conclusion: Between the final results of the beginning and the end, the isokinetic tests show an improvement of the strength peaks. Dallas’ test ascertain an improvement of the scores in the four categories, but no correlation is found between isokinetic gain and improvement of the quality of life explored by Dallas’ score.

Table 1

<table>
<thead>
<tr>
<th></th>
<th>30°/s</th>
<th>120°/s</th>
<th>Dallas Score</th>
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<tr>
<td></td>
<td>FLE</td>
<td>Ext</td>
<td>FLE</td>
</tr>
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<td>30°/s</td>
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<td>0.024</td>
<td></td>
</tr>
<tr>
<td>120°/s</td>
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<td>0.024</td>
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<tr>
<td>Ext</td>
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<tr>
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<td>AVJ</td>
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<tr>
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</table>
Using isokinetic dynamometers for measurements associated with tissue extensibility

Peter J. McNair\textsuperscript{a} and Pierre Portero\textsuperscript{b}
\textsuperscript{a}Physical Rehabilitation Research Centre, Auckland University of Technology, New Zealand
\textsuperscript{b}Institut de Myologie, GH Pitié-Salpêtrière, Paris, France

Traditionally, isokinetic dynamometers have been used to measure variables associated with strength, power and endurance characteristics of muscle. Much less attention has been given to their potential for measuring parameters associated with tissue extensibility. Researchers \cite{1} have commented that there is a need for more information on the prescription of stretching routines to enhance the safety and the results of stretching programs. The use of dynamometers to examine responses to stretching can provide important information allowing a more precise stretching prescription to be instituted. Furthermore, dynamometers can be used as training equipment to facilitate improvements in range of motion.

In this paper, we describe the most common methods to assess soft tissue extensibility with isokinetic dynamometers. We illustrate these methods using studies from the literature, and we provide examples of findings that show how the use of dynamometers in this field have enhanced our knowledge of factors that affect the extensibility of soft tissues. The most common variables of interest obtained from dynamometers are the maximum force, or torque, maximum angle and the stiffness of the system, the latter being measured by the ratio of the change in force to change in angle at different points in the range of motion. As such it may be regarded as quasi-stiffness.

Measurements at the ankle and knee joint have been most common, and across these joints, the procedures are quite similar. At the ankle joint, the methods and their rationale are as follows \cite{2}. Initially, the ankle joint is positioned between 0–45 degrees plantarflexion, and the subject’s knee is fully extended. The KinCom\textsuperscript{\textregistered} dynamometer (Chattecx Corporation, Tennessee, USA) is programmed to move the ankle joint to 80 percent of the subject’s maximum range of dorsiflexion. On reaching this position, a visual check is made to ensure that the heel has not lifted from the foot plate of the Kincom. This range of motion is chosen as testing has indicated that the electromyographic responses of the plantar flexor muscles to stretch increase significantly when these tissues are stretched past this point. We generally measure maximum range of dorsiflexion using manual procedures \cite{3} 3–5 days prior to the Kincom testing session.

Subjects are given specific instructions to relax and not activate their lower limb muscles during the procedure. Surface electromyographic activity from the plantar and dorsiflexor muscles are monitored to ensure that subjects adhere with this request. The EMG data is recorded simultaneously with signals from the Kincom’s load cell and potentiometer at a sampling frequency of 500 Hz, and relayed to a computer for subsequent processing. Generally, the root mean square (RMS) is calculated and normalised to a maximum voluntary isometric contraction recorded at the completion of the experiment. The EMG activity recorded during a trial can then be expressed as a percentage of that recorded during the maximum isometric voluntary activation. If a subject’s EMG data is greater than
one percent of a maximum voluntary contraction, then that subject's data is discarded. In older subjects (>60 years), this criterion is more difficult to achieve, and we have relaxed it to a five percent level [4]. In some instances, we have used EMG biofeedback to provide subjects with a view of their muscle activity. We find that subjects can then often decrease unwanted muscle activity more easily. We have observed that approximately five percent of all subjects cannot lower their EMG activity to appropriate levels. There does not appear to be a pattern of activation in these subjects. In some, it is the stretched muscle that remains active, while in others, the antagonist's activity is problematic.

EMG activity may also be a protective response caused by excessive joint angular velocity. Traditionally, trials are undertaken at very low joint angular velocities (5–10 deg/sec), however, the findings of our work at the ankle joint indicate that angular velocities similar to those attained during gait (25 deg/sec), can be implemented without an EMG response [5]. Other researchers have noted similar findings. For instance, Hufschmidt [6] noted no stretch reflex responses during stretches between 2–20 deg/sec. Only at velocities above 80 deg/sec were these recorded by Hufschmidt [6]. More recently, Lamontagne et al. [7] observed no EMG changes in response to stretches up to 180 deg/sec, however, this study examined responses at joint positions that would place the tissues under limited strain (10 deg. of dorsiflexion at the ankle).

A typical force curve recorded as range of motion increases to 80 percent of ankle dorsiflexion is characterised by a non linear toe like region early in the range of motion in which force is increasing, but at a relatively slow rate. Thereafter, a greater rate of force increase which is more linear is noted. In-vitro studies show that during the toe-like region, un-crimping is occurring in the collagenous tissues, and thereafter additional increases in force are due to strain and slippage of collagen fibrils. In in-vivo studies, the variables of interest are the maximum force, stiffness and the passive energy absorbed as measured by the area under the force-angle curve. In many instances, researchers chose a particular part of the force-angle curve to measure stiffness and passive energy absorbed (eg: final 50 or 10% of the range of motion). In some studies, for example, Gajdosik et al. [4], the authors also recorded force as the joint returned to its starting position. In doing so, they were able to measure the energy loss of the system by calculating the difference in areas under the curves for the stretch and return motion.

Researchers [8] have suggested that improvements in joint range of motion following stretching exercises can be attributed not only to changes in structural parameters, but also to increased stretch tolerance. Stretch tolerance refers to the ability to tolerate the discomfort associated with the stretching of tissue. Stretch tolerance can be examined using isokinetic dynamometers. These experiments use the same methods as presented above with the primary difference being that the range of motion is not limited. In such experiments, we set the range of motion limit on the dynamometer well in excess of what might be possible physiologically.

The joint is also positioned in a manner that would put maximum stretch on the muscles of interest without the joint being at its normal end point. For instance, when measuring stretch tolerance to knee joint extension, the subject is positioned in sitting, and the thigh placed upon a specially constructed pad, triangular in shape. The height of the pad is adjusted so that the lower leg cannot reach the fully extended knee joint position. A firm roll of foam is also placed behind the lumbar spine to maintain the subject's lumbar lordosis and prevent the pelvis rotating posteriorly during the stretching trial. Subjects are also blindfolded and asked to focus upon the sensation of stretch. The knee joint is then set in motion and at the point where the subjects perceive maximal tolerable stretch, they depress the Kincom "cut-out" safety button and motion ceases. Maximum passive knee joint extension, and the associated force is recorded. In a study by Reid and McNair [9], stretch tolerance of the hamstring muscles was measured prior to and after a six week stretching program. The findings showed that both force and angle were increased significantly, as was stiffness in the final 10 percent of the range of motion.

The parameter, force relaxation, has been examined using isokinetic dynamometers. This biomechanical property is associated with lessening the chances of a strain injury [10]. Typically, such experiments use the same methods outlined above, however, the joint upon reaching the final position in the range of motion (eg: 80 percent dorsiflexion) is held there, and force is monitored for a set period of time (eg: 60 seconds). Force relaxation refers to the decrease in peak force that occurs with the limb held at the lengthened position. How force relaxation might reduce strain injuries is unclear, though authors [10] have implied it might promote a greater range of motion for the joint to move. We have used a KinCom dynamometer to assess the decrease in force associated with stretch to the plantarflexor muscles and other tissues stretched during a static hold in a dorsiflexed position. Other authors such as Magnusson and co-workers [11] have focused upon force relaxation.
at the hamstrings. Our findings, like those of others [10, 12] show that force relaxation is non linear, and adheres to a law of diminishing returns. In hamstring muscles, McHugh et al. [12] and Magnusson et al. [13] recorded a decrease of 13–16 percent over 45 seconds, which is similar to our findings at the ankle joint, where the force over this interval was decreased by 17 percent. In most exercise and rehabilitation scenarios, stretching is undertaken for a limited time period. Therefore, it would be of interest to know the time over which the greatest decline in force occurs, as this might constitute the most “efficient” time for holding a stretch. At the ankle joint we have noted that the greatest change was observed in the first 20 seconds [2]. This change is similar to that reported by Taylor et al. [10] who noted that the greatest decline in tension was between 12 and 18 seconds in-vitro, and also similar to in-vivo studies by McHugh et al. [12] and Magnusson et al. [11] that indicated the greatest changes in tension occurred in the first 15 and 20 seconds respectively. Based upon these findings, 20 seconds would be an appropriate duration to recommend for producing the most efficient response.

In many instances, stretching exercises are commonly undertaken using repeated stretching performed in a cyclic manner. These types of stretches have been termed ballistic or dynamic. Few studies have examined changes in biomechanical parameters when tissues are stretched in a cyclic manner. In-vitro research by Taylor and colleagues [14] has shown that peak passive muscle tension decreases notably across cycles of stretch. Similarly, using cadaveric spinal segments, Adams and Dolan [15] reported a steady decrease in resistance to bending with repeated motion. In contrast, an in-vivo study by Magnusson et al. [16] reported an increase in hamstring muscle’s stiffness with repeated motion. Using a KinCom, we have examined the effect of cyclic dorsiflexion at the ankle joint over a two minute period [5]. In this experiment, recreational subjects participated, and the KinCom dynamometer was programmed to move their ankle joint at 5 deg/sec to 80 percent of the subject’s maximum range of motion repeatedly over a 120 seconds. The findings showed that the peak passive force within each cycle of dorsiflexion decreased significantly across time. Qualitatively, the decline in tension was curvilinear and leveled out at approximately 100 seconds. The magnitude of the overall decrease in force was 13 percent.

In the same experiment we also examined the effect of increased joint angular velocity (25 deg/sec) on peak passive force during cyclic motion. Our results showed that when the angular velocity was increased from 5 deg/sec to 25 deg/sec, the peak passive force and average stiffness was increased. These findings were in agreement with the in-vitro work of Taylor et al. [10] and the in-vivo studies of Huffschmidt and Schwaller [17], but in contrast to those of Lamontagne et al. [7]. Over the 120 of cycllical motion, across angular velocities (5 and 25 deg/sec), we noted the rate of decline in the peak passive force was greater at the high angular velocity.

Creep refers to an increase in the length of tissues under a constant or repeated load [18]. Quasi-creep behaviour can be measured using isokinetic dynamometers. Our work in this area has involved repeated cycles of motion in which the KinCom is set to change its direction of motion upon reaching a defined force or torque level. Pilot work has indicated that subjects can accept a force level of 85 percent of the maximum force measured during a stretch tolerance test without discomfort. The range of knee extension across repeated cycles of knee joint flexion and extension is the variable of interest. Our initial experiments show that this variable can be increased by 4.5% across 45 cycles of motion, with the majority of the increases observed in the first 10–15 cycles.

In summary, isokinetic dynamometers can provide valuable information to enhance our knowledge of factors important to increasing extensibility. Specifically, measures can be made of maximal passive force and joint angle, together with quasi stiffness and passive energy absorption. Forces and motion can be recorded over time, and force relaxation or creep can then also be measured. Most research has focused upon using dynamometers in assessment, and further research may explore the use of dynamometers in the treatment of conditions where extensibility and increased range of motion would be valuable.

References


