Original Version

Proprioceptive Neuromuscular Facilitation: Effectiveness in Increasing Range Of Motion in Dancers and Other Athletes

Thesis

Submitted by

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ABSTRACT

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The purpose of the study was to document the effectiveness of the investigator's adaptation of PNF using a specifically designed table with restraints. Presently, no data exists which documents effectiveness of the A&F/PNF technique, nor has the method of video recording been used in a flexibility study. Twenty four volunteer athletes and dancers enrolled at Arizona State University participated in the study. The experimental group consisted of 14 subjects who participated in a flexibility training program during a six week testing period. Ten subjects in the control group were not involved in a training program. A video camera recorded measurements of range of motion (ROM). Markers were placed on hip and ankle joints to pinpoint specific x and y coordinates for exact measurements on a digitized video screen. The findings showed statistically significant gains in range of motion across both groups. The data analysis revealed an increase in ROM ranging from 36% to 38% in hip flexion and 50% to 52% in hip abduction. There was no significant difference between the two groups. There was a continued increase in the initial ROM throughout testing, suggesting a positive result produced from the chronic adaptive effect for both the experimental and control groups.

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CHAPTER ONE
ORIENTATION TO THE STUDY

Introduction

"I could not have won this Olympic gold metal without all your help" are the words still ringing in my ears from this summer's experience as the flexibility specialist with the U.S. Olympic Wrestling team. The man who made this statement was Kurt Angle, the 220 pound wrestler with whom I had worked all summer in preparation for the games in Atlanta. That moment was the culmination of my personal Olympic experience. It was the ultimate confirmation of the profound effect flexibility training can have on an athlete's performance.

Flexibility training is a missing element in physical conditioning, even with dancers and many athletes. Flexibility is an essential aspect for complete fitness and plays a key role in injury prevention. Because stretching is such an essential component, it should be optimized. However, it is often under emphasized or completely overlooked.

Several methods of stretching have been found to improve range of motion. The oldest and most damaging is ballistic stretching. This method incorporates dynamic force application (e.g. bouncing stretching) as a means to lengthen muscle tissue. Unfortunately this activity triggers the dynamic component of the stretch reflex, strongly inhibiting muscle lengthening and perhaps exposing the muscle to microscopic damage. Laban presented four major arguments against ballistic stretching.

These arguments involve the following issues: (a) tissue adaptation; (b) soreness resulting from injury; (c) initiation of the stretch reflex; and (d) neurological adaptation…

When muscle and its supportive tissue are rapidly stretched, they were not given adequate time to adapt... If tissues were stretched too rapidly, lasting flexibility could not be optimally developed (quoted in Alter, M. 1988).

The stretch reflex needs to be minimized for the most beneficial stretch to occur.

The myotatic stretch reflex prevented a muscle from stretching too far too fast, which protected the joint from injury. The stretch reflex was mediated through the muscle spindle cells. Located in the muscle belly, the spindle cells monitor the tonus of the muscle. They sense changes in muscle length and the speed of those changes. When a muscle is lengthened too quickly, the spindle cells are stimulated and reflexively caused the muscle to contract, resisting the lengthening and thereby preventing over stretching of the joint (McAtee 3,4).

Static stretching is the second commonly used method. It involves the use of holding a position from a few seconds to a few minutes. This procedure allows the muscle fibers to relax and lengthen. "Static stretching was often associated with isometric, controlled, or slow stretch" (Alter, M. 85).

The static method is much safer than ballistic, however, it is still not likely to be the most effective. Muscle lengthening requires an outside force. The static component of the stretch reflex represents a natural protective mechanism against over stretching.

A third method of stretching is Proprioceptive Neuromuscular Facilitation (PNF). This method is used infrequently, and is not very well understood by most people. This method uses a partner or other means to resist against an isometric contraction of a specific muscle. According to Alter, this resistance activates the golgi tendon organ. The golgi tendon organ fires and inhibits activation of the muscle. Once active stimulation of the muscle is withdrawn (i.e., once the subject volitionally relaxed) this release allows for a more complete relaxation to occur within the muscle. A much deeper stretch and elongation of the entire muscle can be achieved. Alter states that "proponents of certain PNF techniques claim that individuals afterwards experience a greater ease of passive motion (Alter, M. 90)." Proprioceptive Neuromuscular Facilitation fires the golgi tendon organs, which inhibits muscle activation, releasing the muscular tension.

The practice of PNF "was a treatment modality developed in the late 1940s and early 1950s by Herman Kabat, MD, Ph. D. (McAtee 3,4)." Kabat recommended PNF application with primary assistance of two physical therapists. The present investigator has used an adaptation of PNF technique, (A&F/PNF) on hundreds of people and found it to be superior to all other methods for increasing range of motion. A specifically designed table with restraints holds the subject being stretched in a

stationary position and isolates the working muscle group. The table with restraints allows for the most effective working condition for both the practitioner and the subject being stretched. For the present study, the specific adaptation of the table with restraints, developed by the investigator, was used.

Review of Literature

A thorough search of the literature revealed that there were no published research articles that examined range of motion using video documentation. The majority of studies used either a goniometer, Leighton flexometer or a tape measure. No studies employed restraints during testing. There was, however, a considerable body of literature supporting the investigator's premise that PNF was the superior method for increasing flexibility.

Of the twelve journal articles related to general stretching, nine found PNF to be the most effective method (Byrne, T. 1984, Etnyre, B. & Abraham, L. 1986, Moscov, J. 1992, Nelson, K. & Cornelius, W. 1991, Ostering, L. Robertson, R., Troxel, R., Hansen, P. 1987,1988, Perry, S. 1988, Rivera, M.L. ,1979, Voss, D. 1967). There were several different techniques of PNF that were used to produce significant results. The two approaches that appeared to give the best results were: CRAC, which is an abbreviation for contract, relax, antagonist, contract and CR which is an abbreviation contract-relax . The present study will use the Contract Relax technique.

Surprisingly, there were only a few of articles that were specifically designed to examine stretching as prevention of sports injury. Likewise, journal articles related to improving dancer flexibility were unavailable. In fact, the only article found, considered several other factors (Moscov J. 1992). Static range of motion, leg power, and leg strength were predictors of dynamic range of motion in female ballet dancers. PNF was found to be superior as a means of increasing flexibility.

Statement of Problem

The purpose of the study was to document the effectiveness of the investigator's adaptation of PNF on volunteer dancers and athletes. According to many anecdotal reports, A&F/PNF is an extremely effective procedure, perhaps superior to all previous techniques. Presently, however, no data exists which documents A&F/PNF effectiveness. The present study, therefore, intended to collect and analyze data to gain insight into the efficiency of this technique.

Operational Definitions

For the purposes of this study, the following definitions apply:

Flexibility: the capacity to bend, or flex or extend without breaking (Webster's New World Dictionary, 1990). It refers to the elasticity of muscle and connective tissue and what is achieved by stretching.

Stretch: to extend body or limbs to full length (Webster's New World Dictionary 1990).

Stretch Reflex: "a basic operation of the nervous system that helps maintain muscle tone and prevent injury. The stretch reflex is initiated whenever a muscle is stretched. Stretching a muscle lengthens both the muscle fibers (i.e, the extrafusal fibers) and the muscle spindles (intrafusal fibers). Change in the length the muscle spindles results in the firing of afferent nerve fibers which activate the muscle being lengthened. The muscle that is being stretched, therefore 'contracts' against the stretch (Alter, M. 1990)". There is a static, low level component and a high level component, thus a muscle undergoing rapid lengthening contracts vigorously against the stretch.

Range of Motion: specifically refers to the angle between two bones within a joint, such as a hip or shoulder, and is measured in units of degrees; (Alter, M. 1990). For the purpose of the study the terms flexibility and range of motion will be used interchangeably, however, they do have slightly different meanings.

PNF: a stretching technique in which isometric contraction against resistance is followed quickly by muscle relaxation and then static stretching to achieve greater range of motion (Berardi 224).

A&F/PNF: the researcher's adaptation of the PNF technique using the table with restraints.

Hypothesis

The hypothesis was that when PNF is applied to a stabilized subject, it would elicit a significant increase in ROM. The application of A&F/PNF flexibility training technique in the experimental group would exhibit a greater increase in ROM. The control group in comparison, who received no outside training, would show less improvement.

Assumptions

It was assumed that the subjects were motivated to give their best effort during testing. It was assumed that all subjects complied with instruction not to work out strenuously within a two day period prior to each testing session and truthfully reported any variances. It was also assumed that the experimental subjects would not stretch outside of training class and the control group would not participate in any flexibility training during the six week study as requested. A questionnaire completed by all of the subjects before each testing session verified whether requests were followed and reported any current problems. This enabled the researcher to examine results for possible bias.

Limitations

The subjects for the experimental group were volunteers who were enrolled in DAN 330 Flexibility. The researcher had no control over the amount of outside stretching done by the subjects, however, subjects were requested to limit flexibility training to class experience under the direction of the researcher. The control group were asked not to

participate in flexibility training during the six week testing period. The influence of past or new injuries as well as subject's current soreness could have affected testing results. The age range was dependent on the voluntary participants.

Delimitations

The study focused on ROM of the right hip joint in flexion and the left hip in abduction. It was delimited to the subjects enrolled in DAN 330 Flexibility class who volunteered to participate in the experimental group and to volunteers from outside the class who participated in the control group. Students with extreme range of motion were excluded from the project. The researcher's definition of extreme ROM is hip flexion and adduction at or beyond 175 degrees in the hip joint. No subjects under the age of 18 years were used.

Significance of the Study

There was a general lack of research in the area of flexibility, an aspect of complete fitness that tends to be over looked until an injury occurs. The literature clearly recognizes proper stretching as an important component of injury prevention. Dancers and athletes are poorly informed about the importance of flexibility and the correct methods to increase this crucial element. This study will contribute valuable knowledge about flexibility physiology as developed by the researcher and applied to dancers and athletes.

CHAPTER TWO
METHOD

Preliminary Procedures

Preparation for this project began in Spring 1996 when an arrangement was made for the investigator to teach a class in flexibility for dance major students at Arizona State University. A course plan entitled DAN 330 Flexibility was developed and offered during the Fall semester 1996. A group of twenty enrolled students were pre tested for the ROM in their hamstrings and adductors. Subjects were instructed in the A&F/PNF technique and post tested again at the end of the term. Based upon the pilot work, a prospectus for the thesis was developed. Permission to use human subjects for the present study was obtained from the Institutional Review Board. Subjects were oriented to the study and were asked to sign a consent letter.

Subjects

Subjects for the experimental group consisted of 14 students who were enrolled in DAN 330 Flexibility during the Spring 1997 Semester and volunteered to participate. Ten subjects in the control group included volunteer athletes and dancers who were not currently involved in a flexibility training program. All of the subjects were pre tested for current ROM. None demonstrated extreme ROM and all were included in the study.

Instrumentation

The Department of Exercise Science provided a video camera to record limb movement and a computer to digitize and analyze the video data. A computer was used to calculate the data and analyze the statistics. A monitor was used to view the recorded video tape. An exercise bike was used to warm up the subjects. A table with restraints was used to test the subjects.

Procedures for Data Collection

A video camera was used to record measurements of ROM and the field of filming was calibrated before each testing session. Markers were placed on all of the subjects hip and ankle joints, in order to pinpoint specific x and y coordinates for exact measurement on the digitized video screen. The experimental subjects received training in A&F/PNF technique. Subjects were tested at three different intervals, two weeks apart, on February 6, 20, and March 6, 1997 for the experimental group and the control group were tested on February 13, 27 and March 13, 1997. Measurements were taken of the right hip joint for hip flexion (hamstring), and left hip abduction (adductor). A pre test for initial ROM level was evaluated for each subject before actual testing began. Acute effects as well as chronic effects were tested and examined. Exact measurements were determined by examining the digitized tape recorded by the video camera. The researcher viewed and selected key points on the tape to determine starting and ending points for each measurement taken. To get the most accurate reading, three separate points were chosen for each marker, with the videotape automatically advancing 3 frames and then an average was taken.

For the subjects' safety, and to raise their body core temperature for optimal results, subjects were properly warmed up by riding an exercise bicycle for a five minute period at a moderate pace, prior to being measured. Subjects were instructed to wear warm clothing such as sweat pants and shirts to help maintain their warmth.

Subjects lay in a supine position with the left leg restrained to the table. A video record was made of ROM of the right leg in hip flexion. Subjects lay on their right side, for 0measurement of left hip abduction. After subjects had been tested for initial ROM in hip areas, the A&F/PNF technique was administered three times per area. Subjects were instructed to use 75% effort while isometrically contracting in six second intervals against the researcher's resistance. A brief pause after each contraction provided a relaxation phase. A deep exhalation was accompanied by an increase in ROM facilitated by the researcher after each relaxation period and a static stretch was held for 15 seconds. After the third and final contraction there was an extended period of static stretching for 30 seconds.

Treatment of Data

The findings were recorded for each measurement obtained from the digitized video tape. Each subject had a separate file and notes were made for each testing session regarding anything that needed to be considered as a contributing factor to the results. After all the data were collected at the end of the testing, a specific computer program was designed to calculate all of the measurements and analyze the data. The average for the entire class, both experimental and control groups, and individuals were

evaluated. The percentage of improvement in ROM was calculated in each joint and in each subject. The acute effects resulting from one session (training effect from initial ROM improvement) versus the long range chronic effects to increase ROM (training effect from extended A&F/ PNF application) were evaluated. The findings were analyzed to determine the significance of improvements that occurred and what patterns appeared.

Design and Analysis

An experimental design with repeated ANOVA was used for this study. Two types of data were considered: longitudinal, using the absolute data from one group versus the other, and the data from individual subjects. Effects across time were examined. ROM recorded on video tape were digitized and were carefully analyzed to determine testing results. Each measurement provided four independent factors for each test session. The spreadsheet Excel was used for data collection and for final analysis.

CHAPTER THREE
RESULTS

The Experimental Group

Chronic adaptive effect for the Group

The findings revealed an average increase in ROM for hip flexion of 38.7 percent for the experimental group, with a standard deviation of 11.6 percent when measurement was taken from initial test to post test during the six week period. (See Table 1). The hip abduction increased in ROM an average of 52.1 percent, with a standard deviation of 12.3 percent from the initial test to the last trial. (See Table 2).

The chronic adaptive effect showed a continued improvement for most subjects which was demonstrated by a greater initial range in hip flexion prior to the next test session of PNF application with an increased ROM average of 14.5 percent. (See Table 3). Hip abduction increased an average of 20.6 percent.

Individual Chronic Adaptive Effects

Individuals showed an increase in ROM that ranged from 20.6 percent to 64.8 percent in hip flexion and from 24.9 percent to 66.6 percent in hip abduction at the end of the study. (See Table 4). The same subject showed a gain in hip abduction of 60 percent. (See Table 5). A gain in initial ROM of 28.8 percent in hip flexion also occurred. (See Table 6). An increase of initial ROM in hip abduction of 41.1 percent also occurred. (See Table 7).

Acute Adaptive Effect for the Group

There were slight variances with some individuals that had lower initial measurements before PNF was re-administered on the second or third testing sessions. This could be due possibly to the subjects reported current muscular soreness or illness at the time of testing.

The Control Group

Chronic Adaptive Effect for the Group

The findings revealed an average increase in ROM of 36 percent for hip flexion for the control group, with a standard deviation of 17.9 when the measurement was taken from the initial test to post test during the six week period. (See Table 8). The hip abduction increased an average of 51.1 percent from the initial test to the last trial, with a standard deviation of 12.9. (See Table 9).

The chronic effect adaptive also appeared to cause a continued increase in initial ROM for most subjects prior to re-administered application of PNF in the control group. The hip flexion ROM average increased 14.3 percent and abduction initial range increased 36.2 percent. (See Table 10).

Individual Chronic Adaptive Effects

Individuals showed a large variance of hip flexion ROM increase that ranged from 5.4 to 69.6 percent. In hip abduction the ROM gain ranged from 33.7 to 71.8 percent. (See Table 11).

Acute Adaptive Effect for the Group

There were slight variances with some of the individuals' initial measurements before PNF was re-administered on the second or third testing sessions. This could be due possibly to subjects reported current muscular soreness or illness at the time of testing.

Comparison Between the Experimental and Control Group

When an average was taken from the initial test to the post test during the six week period, 2.6 percent less hip flexion gain. Hip abduction in the experimental group showed a variance of 1 percent greater gain over the control group. Both groups demonstrated continued improvement of initial ROM from chronic adaptive effect. There was a difference of .2 percent less ROM increase in hip flexion for the control group, but a 15.7 greater increase in initial ROM for hip abduction in the control group. The comparison between the two groups in regard to the acute adaptive effects showed slight variances. The individual chronic adaptive effects for both groups showed large variances and the acute adaptive effects showed slight variances.

CHAPTER FOUR
DISCUSSION

The investigator discovered a number of interesting findings as the test results were analyzed. The greatest increases were found in ROM from the initial test to the post test, in both groups. This clearly demonstrated the effective contribution to flexibility gains of the specific adaptation of the A&F/PNF technique. This was evident in the results from the chronic and acute adaptive effects in both groups, also with the continued improvement of initial ROM. Therefore, the hypothesis that PNF applied to a stabilized subject would elicit significant gains in ROM was proven for all subjects. However, significant gains expected between the experimental group, (which were being trained in flexibility) and the control group, (which were not being trained), did not appear. Relatively small gains in the experimental group may be attributed to the lack of actual training time between testing sessions and possibly the lack of consistency of training within the sessions. The large discrepancy in initial ROM hip abduction for the control group may be because most of the subjects were dancers who came from a rehearsal or class and were more warmed up than the subjects who simply rode the exercise bicycle prior to being tested. Another factor influencing this outcome was that hip abduction is more natural to these particular subjects.

For future studies the researcher recommends that a longer period of training be allowed between testing sessions. Also, the training sessions should include a specific procedure regarding the number of repetitions and consistency in how PNF is applied as well as who applies it. Further, additional studies could replicate the present study

using different populations, different age groups, and other joints. Hopefully, the present study will be the first of many to verify the effectiveness of PNF and the A&F/PNF system as a superior method of increasing and sustaining increases in ROM.

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