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Effects of proprioceptive neuromuscular facilitation stretching on the sit and reach test in fitnessgram

Ryan William Pacheco

EFFECTS OF PROPRIOCEPTIVE NEUROMUSCULAR FACILITATION STRETCHING ON THE SIT AND REACH TEST IN FITNESSGRAM

A Project

Presented to the

Faculty of

California State University,

San Bernardino

In Partial Fulfillment

of the Requirements for the Degree

Master of Arts

in

Education:

Kinesiology

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Approved by:

[redacted]

HoSung So, First Reader — 6/24/2008 Date

[redacted]

Stephen Kinzey, Second Reader

ABSTRACT

The physical condition of the students in this generation is worse than ever before. It is important to find ways to improve the fitness levels of the students to help reduce the poor fitness testing, or at least help them feel better about themselves. The purpose of this project was twofold: to review the literature pertaining to proprioceptive neuromuscular facilitation (PNF) stretching techniques and its benefits for flexibility; and, the back-saver sit-and-reach (BSR) portion of the annual FITNESSGRAM physical fitness test was examined in an effort to discover the benefits of PNF stretching prior to the test. Of the 5 components of physical fitness; muscular strength, muscular endurance, cardiorespiratory fitness body composition, and flexibility, flexibility can be the most beneficial to a healthy lifestyle because it will help prevent injuries throughout the lifetime. This project was accomplished by reviewing the literature using the following databases: ebscohost, pe index, and pubmed. For this project, it was questioned that PNF stretching will improve range of motion, and therefore the percentage of passing scores on

the BSR portion of the FITNESSGRAM. The majority of research surveyed indicated that range of motion does increase immediately after a bout of PNF stretching.

ACKNOWLEDGMENTS

I would like to express my sincere thanks and appreciation to the professors at California State University, San Bernardino for all their help and support in the completion of this project. I would especially like to thank Dr. Hosung So, my first reader, for his support and guidance and Dr. Stephen Kinzey, my second reader, for his patience and support through this process of growth.

Special thanks go to all my friends that didn't give me too much trouble on those nights I needed to stay home and do research.

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Finally, I want to thank my wife Jennifer for her patience and love. Without her support, this would not be possible.

DEDICATION

To my beautiful wife, who is always there for me and helped to keep me on track. You are a wonderful and amazing person and I thank you for your support, your honest advice, and in believing that this project can be completed. Thank you for giving me that extra push.

To my parents, who always said I was smart and that I can do anything. Thank you for your support and encouragement.

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INTRODUCTION

Statement of the Problem

Our students are becoming increasingly more overweight and less active. Physical Education classes are geared towards improving our students' knowledge about physical activity, lifetime activities to promote fitness, and an overall knowledge of how to stay healthy. However, some students just do not have the motivation, athletic abilities, or have small medical concerns that would prevent ever participating fully in physical education classes; therefore possibly receiving a less than passing grade in the class.

The State of California employs the FITNESSGRAM as its physical fitness test in 5^{th}, 7^{th}, and 9^{th} grades to ensure all students are on their way to a healthy quality of life. Each of the 6 tests included in the physical fitness test have a Healthy Fitness Zone (HFZ) that according to O'Connell (2007):

> It represents the level of fitness thought to provide some protection from the potential

> health risks imposed by a lack of fitness in this measure. The HFZ reflects reasonable levels of fitness that can be attained by most students that participate regularly in various types of physical activity. (p.1)

Therefore, numerous scores in the HFZ by a student reflect a reasonable level of overall fitness.

As of January 1, 2008, the California Department of Education has added to the Educational Code (section 51241 b, d), stating if a student is able to score in the HFZ in any 5 of the 6 tests included in the physical fitness test will receive a 2-year exemption from physical education courses. This will allow students that do not wish to enroll in a physical education course an opportunity to opt out of the class. Students that have only passed 4 of the 6 areas in the HFZ will have to continue enrolling in a physical education course until 2 years have been successfully completed.

Students needing one area to satisfy in the HFZ to be exempt from physical education, if that one area is the flexibility portion, might not have the right opportunities available to stretch to their full

potential. Numerous journal articles, such as Measurement in Physical Education and Exercise Science, Sports Medicine, and Physician and Sports Medicine have reported that utilizing proprioceptive neuromuscular facilitation stretching can greatly increase flexibility immediately.

According to Greico (2002), improved flexibility can help with the reduction of injuries and can enhance performance; therefore resulting in a healthier lifestyle. Greico also concludes PNF stretching is superior to other stretching methods and provides additional benefits other than increases in range of motion. She also explains how PNF stretching can be done with a partner, such as a teacher, or solo, as in a classroom setting.

According to Walker (2007) in the stretching handbook, PNF stretching is a more advanced form of stretching. He explains it is also an excellent isolator of muscle groups as well as increasing flexibility. The PNF stretching process is discussed, and in its entirety, can be completed in only 2 minutes. This makes it easy to implement with students in a timely manner.

Knowing which stretching techniques to employ before the FITNESSGRAM will allow physical education teachers a better opportunity to have their students score successfully in the HFZ and have a better chance at continuing a healthy lifestyle. Teachers can expect a better understanding of PNF stretches, strategies and recommendations to implement successfully it into class, and a better overall knowledge of stretching.

Purpose of the Project

The purpose of this project was twofold: to review the literature pertaining to proprioceptive neuromuscular facilitation (PNF) stretching techniques and its benefits for flexibility; and the back-saver sit-and-reach (BSR) portion of the annual FITNESSGRAM physical fitness test was examined in an effort to discover the benefits of PNF stretching prior to the test.

Research Question

The question that was researched for this study was to determine if the current literature on PNF stretching supports the notion that it could increase ROM at the hip

joint; thereby, allowing the inclusion of PNF prior to the performance of the BSR test in an effort to increase the percentage of passing students on the FITNESSGRAM.

Scope of the Project

This project was intended for every physical education teacher who wants better results on the FITNESSGRAM. The journals that focused on stretching techniques other than PNF and other aspects of the FITNESSGRAM not including the flexibility portion were excluded. In addition, journals covering flexibility of joints other than the hip joint were not used. Information was gathered from numerous scholarly journals, such as Measurement in Physical Education and Exercise Science, Journal of Sports Medicine, and Physical Therapy Reviews. Articles were located using several search engines such as EBSCOHost, PUBMED, and PE index. The California Department of Education website was also used as a reference.

Limitations of the Project

Some of the limitations of this study were the focus primarily on the improvement percentage and not on the distance of improvement. Other limitations included the age of the subjects used in the studies and the relation of studies to the FITNESSGRAM. Major peer-reviewed journals, physical activity magazines, and fitness websites were used for this study.

Definition of Terms

A. PNF is defined as Proprioceptive Neuromuscular Facilitation and is "a more advanced form of flexibility training that involves both the stretching and contraction of the muscle group being targeted." (Walker, 2002).

B. HFZ is defined as a Healthy Fitness Zone and "represents the level of fitness thought to provide some protection from the potential health risks imposed by a lack of fitness." (California Department of Education [CDE], 2007, p.1)

C. FITNESSGRAM is defined as "the health related fitness assessment" (Hartman, 2003, p.72) that is

used by the state of California to assess the health of students in grades 5, 7 and 9.

D. BSR is defined as the back-saver sit-and-reach which is a single-leg hamstring stretch designed to ease pressure on the lower back.

E. ROM is defined as range of motion which is the angular distance that can be moved at a body joint at any given time.

F. BMI is defined as the body mass index. It is a number that results from a formula taking into account the individual's height and weight. A healthy BMI score is between 18 and 25. The formula for BMI is ((weight in pounds / height in inches) x 703)

CHAPTER TWO

METHODS

Research began by searching through PUBMED via the California State University web site for any information about PNF stretching. The search terms that were used were 'proprioceptive neuromuscular facilitation and hip'. Of the 18 articles returned, 8 were used in this study. Other search terminology used at PUBMED was 'proprioceptive neuromuscular facilitation hamstring' which yielded 13 sources, and 'proprioceptive neuromuscular facilitation ROM' which yielded 11 results. Each of the preceding two searches had many of the same articles; however several new sources were discovered. PE index was also used. The same terminology was used and similar resources were found. EBSCO host was used as another resource locator. The same terminology was used; however significantly more sources, 95, were found. After sifting through irrelevant articles and adding a search using 'FITNESSGRAM flexibility', 10 additional articles were found. Further information covering the FITNESSGRAM testing methods, procedures and grading protocols was

also retrieved from the California Department of Education website and FITNESSGRAM testing manual. The articles that were found on EBSCO Host were searched through in the CSUSB library and reviewed for content. The articles that had relevance were copied, noted, and included in the bibliography. The journals Measurement in Physical Education and Exercise Science, Journal of Strength and Conditioning, Journal of Sport Rehabilitation, and the Research Quarterly for Exercise and Sport, among others, were used for the study. The FITNESSGRAM reference guide was also used as a key source to gather information for this study. Many common factors constantly appeared in the journals. The commonalities were an improvement of range of motion, immediate benefits, and ease of use. It was then decided that the main focus of the study was to prove how effective PNF stretching can be, the ease of which it can be implemented by physical educators, and the benefits in ROM after stretching.

CHAPTER THREE

REVIEW OF LITERATURE

Fitnessgram

In the FITNESSGRAM reference guide, Welk and Meredith (2008) explain that the FITNESSGRAM is "the national educational assessment, data management, and reporting software program (chap.1)". The FITNESSGRAM is used to assess the health levels of school aged children and was developed by the Cooper Institute "in response to the need for a comprehensive assessment protocol" (chap.1). They go on to explain that it:

> Includes a variety of health-related physical fitness tests designed to assess cardiovascular fitness, body composition, muscle strength, muscular endurance, and flexibility. (chap.1)

A one-mile walk/run test is used to assess cardiovascular fitness, BMI to assess body composition, push-ups to assess muscular strength, sit-ups to assess muscular endurance, and the BSR to assess flexibility. "Scientific information is used to determine the amount of fitness needed to meet minimum health levels" (chap.1). They

continue, "FITNESSGRAM uses a HFZ to designate the range of fitness scores associated with good health" (chap.1). The FITNESSGRAM can be used as early as 3rd grade where students can become familiar with the various aspects of fitness. Although, Welk and Meredith (2008) caution that "more formal testing is not recommended until the 4th grade" (chap.1). They reason this by stating "standards of performance are not reliable prior to this age nor is student understanding of the meaning of results" (chap.1). The FITNESSGRAM is implemented in the state of California in grades 5, 7 and 9.

The goal of the FITNESSGRAM, according to a news release from the CDE (CDE state, 2007) is:

> To facilitate learning about physical activity and physical fitness concepts in order to increase the likelihood students will adopt lifetime patterns of physical activity. (p.1)

The release also states "2007 test scores show a 1.5% increase in 5th grade students' scores, a 1.3% increase in 7th grade students' scores, and a 2.7% gain in 9th grade students' scores compared to last years scores" (p.1). A slight improvement is seen, however; the overall scores

are still significantly lower than where they should be. State Schools Chief Jack O'Connell explains in the CDE news release:

> While I'm pleased these numbers are moving in the right direction...this annual fitness test serves as an important reminder to all of us that the majority of our students are not in good physical shape. (p.1)

There is a need for something to help improve students' scores. "The message from these results is clear - our children and youth need more physical activity in their daily lives" (p.2).

In the state of California, the FITNESSGRAM was administered to all 5^{th} (N = 461,404), 7^{th} (N = 461,235), and 9^{th} (N = 447,676) grade students (see appendix A). Over 1.37 million students participated in the BSR portion of the FITNESSGRAM and only 71.8% passed in the HFZ.

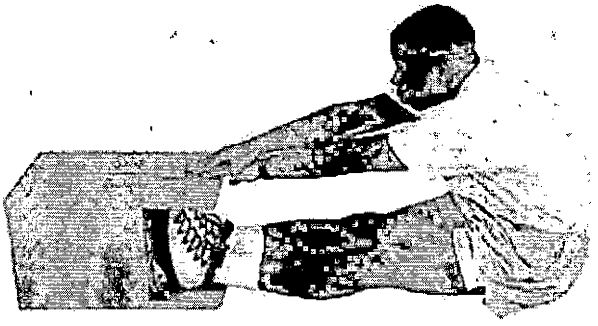

Figure 1. Example of Sit-and-Reach Test.

The statewide results go on to show 44% of students passed only 4 or fewer of the 6 FITNESSGRAM tests. There are no available statistics that show what percentage of the 600,000 students statewide that did not reach the HFZ in at least 5 of the tests, did not pass the BSR portion of the FITNESSGRAM as well.

One of the tests involved with the FITNESSGRAM is a test called the back-saver sit-and-reach (BSR). The BSR checks the flexibility of the hamstring muscle and the ROM at the hip joint. Hartman and Looney (2003) attempted to examine "the norm-referenced and criterion-referenced reliability and validity of the BSR" (p.71). Their study looked at 197 elementary students, both boys (n=87) and girls (n=92). Hartman and Looney conducted a variety of tests on the students to determine hamstring flexibility.

In their testing, they compared various methods of flexibility tests to check range of motion (ROM). The BSR was completed following the FITNESSGRAM test manual:

> Participants sat at the sit-and-reach box with one leg fully extended and the foot flat against the end of the box. The other knee was bent, with the sole of the foot flat on the floor 2-3 in. to the side of the straight knee. (p.77)

The students participated in the BSR on 3 successive attempts. The high score of the 3 tests was used. The results from the tests showed that only 52% of the female students passed with a score in the HFZ while 81% of the boys tested into the HFZ. The study went on to discuss "the BSR appears to be similar to the Double-Leg Sit-and-Reach in that it is a test of hamstring flexibility and not low back flexibility" (p.86). They also give a suggestion that the "standards should be re-examined and may need to be adjusted upward for boys and downward for girls to provide a better degree of classification" (p.86). The BSR does test the flexibility of the

hamstring muscle and using a pre-test stretch to elongate the hamstring muscle prior to the test could help improve test scores.

The importance of passing 5 out of the 6 FITNESSGRAM tests is now, effective January 1, 2008, students can be exempt from physical education courses in high school. The California Educational Code (Section 51241) states "the two-year exemption from physical education courses is available if the student satisfies any five of the six areas of the PFT administered in grade 9" (CDE standards, p.1). This would decrease the class sizes of physical education classes in high school, making it easier on the teachers to reach those who need the instruction.

Proprioceptive Neuromuscular Facilitation

To help those in need of instruction that would help improve flexibility, *American Fitness Magazine* published an article (Grieco, et al., 2002) that provided training suggestions related to stretching and flexibility. Grieco states "for the professional and recreational athlete, improved flexibility decreases the chance of injury and enhances performance" (p.37). She explains that "PNF is

not only a superior style of stretching, but has benefits beyond improving flexibility and range of motion" (p.38). She gives background and history behind PNF techniques. PNF was developed back in the late 1940's by numerous doctors "as a treatment modality for paralysis patients" (p.38). Grieco explains "PNF is a specific flexibility protocol using a combination of isometric contractions and stretching techniques" (p.38). PNF is a technical procedure but can be taught to anyone. "PNF stretching is performed best with a partner" (p.38), such as a teacher or instructor, "but most stretches can be performed alone" (p.38). Such as, "if no partner is available, wrapping a towel around the foot or ankle and holding the ends of the towel can achieve a similar stretch" (p.39). Therefore, PNF stretching can be performed with partners or solo, making it ideal for all situations.

Thestretchinghandbook.com (Walker 2007) goes into details of PNF stretching and how to implement the stretches. PNF "is a more advanced form of flexibility training that involves both the stretching and contraction of the muscle group being targeted" (p.1). Walker goes on to explain "it is also excellent for

targeting specific muscle groups, as well as increasing flexibility" (p.1), such as the hamstrings muscle group used in the BSR test. Walker describes the process of how to perform a PNF stretch:

> The muscle group to be stretched is positioned so that the muscles are stretched and under tension. The individual then contracts the stretched muscle group for 5-6 seconds while a partner, or immoveable object, applies sufficient resistance to inhibit movement. (p.1)

He continues:

> The contracted muscle group is then relaxed and a controlled stretch is applied for about 30 seconds. The muscle group is then allowed 30 seconds to recover and then the process is repeated 2-4 times. (p.1)

With regard to the timing on the hold-relax part of the stretch, Walker explains:

> Although there are conflicting responses to the question of how long should I contract the muscle group for and how long should I rest for

> between each stretch, I believe (through a study of research literature and personal experience) that the above timing recommendations provide the maximum benefits from PNF stretching. (p.2)

Bonnar, Deivert and Gould (2004) conducted a study that looked at the time for the hold-relax portion of the PNF stretch. They used 60 active male volunteers (18-29) that were injury free for at least 6 months prior to the study. They were tested in the PNF stretch with hold-relax times of 3 seconds, 6 seconds, and 10 seconds. The results reflect "no significant difference between the 3 isometric contraction hold-time groups on the baseline passive flexibility measurement" (p.260). The results also showed "The average of the PNF stretch trials for all 3 groups was significantly higher than the baseline average of each group" (p.260). Of all tests conducted, PNF achieved the greatest results in ROM improvements. The improvement in flexibility immediately after the PNF stretches were implemented was an average of 10° in ROM improvement, which translates to upwards of an inch on the BSR test. "This study supports previous findings

where the utilization of a PNF stretching technique produced positive gains in range of motion" (p.260). The final finding from the study was "Although all 3 conditions produced significant gains in range of motion, it seems that the 3 second isometric contraction hold time would be the most efficient choice" (p.261). This would make PNF stretching practical and applicable in the classroom so it could be done easily and effectively, with or without teacher assistance.

Carter, Kinzey, Chitwood, Cole (2000) produced a study to determine if PNF alters hamstring muscle activity during response to rapid elongation. The study chose 24 women with an average age of 21. There were 2 groups for testing. The control group used no PNF intervention before testing, and the treatment group participated in a bout of PNF stretching prior to testing. The results reflect that PNF stretching reduced muscle activity in the hamstring muscle:

> PNF in the biceps femoris caused a decrease in muscle activity associated with the response to rapid stretch; specifically, the post-treatment

value was lower than both the pre-treatment value and both the control values. (p.273)

Less muscle activity at the time of a stretch will allow the muscle to elongate more. Carter also explains why this occurs:

> Muscle spindles are desensitized when a muscle is held in a stretched position for a prolonged period of time. During this time the muscle spindles habituate, signaling is reduced, and a greater muscle length can be obtained during the stretch. (p.275)

A review by Sharman, Cresswell, and Reik (2006) sought to determine the mechanisms and clinical implications of PNF stretching, along with other types of stretches:

> PNF, static and ballistic stretching are all effective at enhancing joint ROM; however, PNF stretching characteristically yields greater gains, which may even occur at a faster rate than that of static stretching. (p.930)

The research done by Sharman et al. showed that "one repetition of PNF is sufficient to increase ROM with an expectant change in ROM from anywhere between 3° and 9°,

depending on the joint" (p.935). They continue, "regardless of the duration of the stretching intervention, changes in ROM will occur" (p.935). The conclusion from the review of research by Sharman et al. is that "PNF is the most effective means to increase ROM by way of stretching, particularly in respect to short-term gains in ROM" (p.936). Using PNF in the classroom setting prior would be effective since the time it is applied and the number of repetitions used is not a large factor of the ROM benefits.

Additional research also indicated that PNF stretching greatly increases ROM immediately after the stretching is completed. (Bonnar, 2004), (Burke, 2001), (Cornelius, 1992), (Cornelius, 1992), (Cornelius, 1995), (Feland, 2004), (Funk, 2003), (Greico, 2002), (Hinton, 2007), (Klein, 2002), (Mitchell, 2007), (Osternig, 1990), (Sady, 1982), (Sharman, 2006), (Spernoga, 2001), (Walker, 2008), (Weerapong, 2004), (Williams, 2004), (Worrell, 1994). (See Appendix B).

CHAPTER FOUR

RESULTS

After completing the review of literature, this study focused on the improvement of ROM immediately after a bout of PNF stretches. This would be the most practical application for PNF stretching use to improve BSR scores.

According to Welk and Meredith (2008) in the FITNESSGRAM activity guide, there was a need for a consistent and comprehensive assessment protocol to determine the health of the youth. The FITNESSGRAM uses scoring protocols determined by scientific information to designate the range of scores that lead to good health. The FITNESSGRAM can be used at any age after 3rd grade but is used in the school system throughout grades 5, 7, and 9.

According to the California Department of Education (CDE State ed., 2007), the goal is to increase the chance that students will adopt patterns of physical activity which will lead to good health. The report states that there is very little improvement over the last several years on the overall fitness levels of students. The

release states the scores are significantly lower than where they should be. The State Schools Chief, Jack O'Connell, claims that there is a need for something to help improve the overall results of the students.

According to the annual FITNESSGRAM results report from the California Department of Education (results state, 2008), only 71.8% of the students statewide passed the BSR portion of the FITNESSGRAM. The results also indicate only 56% of students scored in at least 5 out of the 6 Healthy Fitness Zones. The report shows there is a great deal of improvement needed.

According to Hartman and Looney (2003), the BSR test for flexibility is a reliable test for hamstring muscle group flexibility and does not involve the flexibility of the lower back.

According to the Educational Code of California (Section 51241), students can now be exempt from physical education classes in high school if they pass the FITNESSGRAM in 5 out of the 6 Healthy Fitness Zones. This will allow physical education teachers the possibility to concentrate on those students that need the assistance

and help and allow those that do not need the assistance to opt out by passing the FITNESSGRAM.

According to Keating and Silverman (2004), 83% of teachers nationwide implemented physical fitness tests. 91% of the teachers involved assist the students in preparing for the test, so they will be able to achieve the highest score possible. The teachers support the students. The report also showed 97% of the teachers make sure their students try their best on the assessment.

According to Bonnar, Deivert, and Gould (2004), the time of the hold-relax portion of the stretch does not matter with regard to improvement of ROM. The results did show, no matter the time of hold, improvements are still seen. On average, immediately after a bout of PNF stretching, the study showed an improvement of 10° with respect to range of motion. The improvement would result in a difference of 1-2 inches in the BSR test.

According to Carter, Kinzey, Chitwood and Cole (2000), PNF stretching reduces the muscle spindle activity in the hamstring muscle group. The results reflect the post-test results were lower than all other values in the control or treatment groups. The study

shows, as a muscle is held in the stretch position, the spindles habituate, which results in greater muscle length. This would also improve scores on the BSR test.

According to Sharman, Cresswell, and Reik (2006), PNF stretching results in greater gains than static stretching, commonly used in physical education classes, and ballistic stretching, commonly used by students because they are unaware of the proper techniques of how to stretch. The results reflect that it only takes one bout of PNF stretching to achieve gains in ROM, anywhere from 3° to 9°. The report concludes that PNF stretching is the most effective way to achieve increases in ROM, especially with regard to short-term gains. The time required and the results achieved from one bout of PNF are noticeable and practical for a classroom environment.

According to Spernoga, Uhl, Arnold, and Gansneder (2001), "A 1-time, modified hold-relax stretching protocol was effective in increasing hamstring flexibility" (p.47). They continue to explain that "the gains in ROM lasted for only 6 minutes" (p.47). The continued to explain that "a one-time, modified hold-relax stretching protocol was effective in increasing

hamstring flexibility as measured by active knee extension" (p.47).

According to Sady, Wortman, and Blanke (1982), "PNF may be the preferred technique for improving flexibility, and that flexibility training results in an increased consistency of flexibility scores" (p.263).

According to Cornelius and Handis (1992), "the modified PNF stretching technique can be a very effective technique for athletes who are attempting to increase the ROM in their joints" (p.113). They continue to state "modified PNF has been reported to provide a greater increase in ROM than conventional stretching techniques" (p.113).

According to Cornelius, Ebrahim, Watson, and Hill (1992), "post hoc analysis revealed that three modified PNF techniques resulted in greater ROM that the passive stretching technique" (p.313).

According to Cornelius, Jensen, and Odell (1995), "All PNF treatments were effective for increasing ROM. One or two trials of PNF improve ROM and avoid increasing systolic blood pressure" (p.228).

According to Burke et al (2001) "modified PNF training alone or in conjunction with heat or cold thermal agents resulted in significant increased in hamstring length" (p.18).

CHAPTER FIVE

CONCLUSIONS

The majority of studies consulted showed an immediate and noticeable improvement in range of motion after proprioceptive neuromuscular facilitation stretching. Studies using from 30 seconds during the hold-relax time down to 3 seconds for the hold-relax time both resulted in measurable differences in ROM. The time that the PNF stretch is held for has no bearing on if improvements are seen after stretching is completed. The studies also showed that the amount of repetitions used in the entire bout of PNF stretching has no significant impact in the increase of ROM. The results of these studies imply that PNF stretching, regardless of the time or number of repetitions, improves ROM after stretch occurrences. The research also shows that the back-saver sit-and-reach test used by the FITNESSGRAM is appropriate in determining the ROM of the hamstring muscle group, and not that of the lower back. Since PNF is shown to be an effective target stretch of large muscle groups, the hamstring muscle group can be targeted and stretched

properly. The research also implies that successful bouts of PNF stretching can be completed by either a partner or as an individual. Detailed descriptions were given of exactly how to complete PNF stretching both dual and solo. According to research, utilizing PNF stretches is viable in an environment with an instructor teaching PNF stretch techniques and participants following along, such as a classroom setting prior to the BSR test.

Recommendations

To implement PNF stretching prior to the FITNESSGRAM, the teacher will need to have one day set aside for teaching the stretching procedures for PNF stretches, and another day to complete the testing. On the day for instruction, the teacher will need an open area with mats or grass for the students to lie down on, and a piece of fabric or rope 5 feet long. The teacher should have the students seated during instruction. The important points that the teacher needs to relay is what occurs during a PNF stretch, why PNF stretch, and most importantly, how to PNF stretch. To show students how to complete the PNF stretch on their own, have the students

lie on their backs. The teacher is to be walking among the students while having students complete the following directions. The students should lay back, place one foot flat on ground with foot bent, the other foot straight in the air. The rope or fabric is to be placed around the Achilles portion of the ankle with each of the ends in the hands of the student. The students need to tighten their hamstring muscle of their straight leg by attempting to push their ankle to the floor while the hands holding the rope or fabric pull against the foot to prevent it from going to the floor. The rope or fabric is used as a restraint which allows the hamstring muscle to flex without moving.

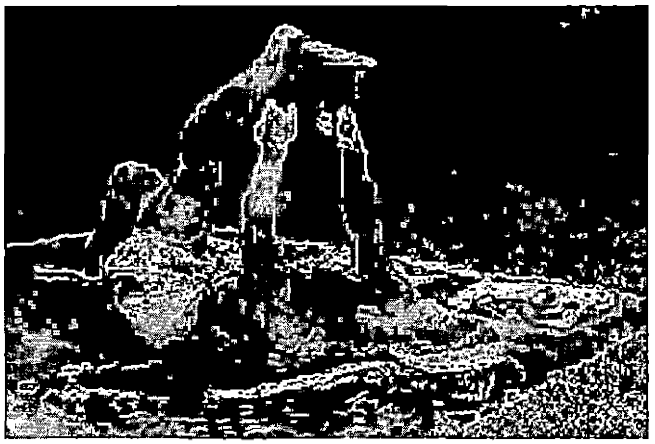

Figure 2. Example of Individual Proprioceptive Neuromuscular Facilitation Stretching.

While the hamstring muscle is being contracted, it become desensitized to the stretch and when relaxed, will stretch a little bit further. Explaining this to the students and showing them the proper techniques will allow for the second day to go smoothly. On day 2, the students should be sitting down waiting for their turn. While two students start the personal PNF stretches, the teacher should be describing how the class will be conducted. When the teacher is finished, the students that have already started stretching should be finished. Since completing the BSR test only takes 1-2 minutes per student, there should always be two students off to the side doing their personal PNF's. As one student finishes the BSR, another should be called up to begin personal PNF. The cycle for a class of 35 should take about 45 minutes. The CDE shows students are unhealthy and are also not improving at a sufficient rate. Over 40% of students are considered unfit, according to the assessment protocols for the FITNESSGRAM. If improvements are to be seen, they need to start at the most practical location; the easiest. Teachers are shown to want the best for their students and to give them all the

opportunities possible to be successful on physical fitness tests. Teachers can implement PNF stretching prior to BSR testing and assist students in achieving higher success rates on the BSR portion of the FITNESSGRAM. As students become successful on more portions of the FITNESSGRAM, they will be allowed to opt out of physical education classes in high school. The removal of the students that are fit and healthy, will allow room and time for physical educators to concentrate on those students in need of a healthy and fit lifestyle. More studies are needed to show the results of implementation in a classroom setting, results of school-aged children after PNF stretching with various time and repetition variances, and the reliability of students completing PNF stretches on themselves to the best of their ability as to achieve the best results.

APPENDIX A

2006-2007 CALIFORNIA PHYSICAL FITNESS REPORT

SUMMARY OF FITNESSGRAM RESULTS

	Grade 5			Grade 7			Grade 9		
Physical Fitness Area	Total[1] Tested	% In HFZ	% Not in HFZ	Total[1] Tested	% In HFZ	% Not in HFZ	Total[1] Tested	% In HFZ	% Not in HFZ
Aerobic Capacity	461,404	62.7	37.3	461,235	62.2	37.8	447,676	55.5	44.5
Body Composition	461,404	67.9	32.1	461,235	67.7	32.3	447,676	68.7	31.3
Abdominal Strength	461,404	80.2	19.8	461,235	83.5	16.5	447,676	84.0	16.0
Trunk Extensor Strength	461,404	87.9	12.1	461,235	89.6	10.4	447,676	87.9	12.1
Upper Body Strength	461,404	68.5	31.5	461,235	70.1	29.9	447,676	72.2	27.8
Flexibility	461,404	68.1	31.9	461,235	73.9	26.1	447,676	73.6	26.4
	Grade 5			Grade 7			Grade 9		
Number of Physical Fitness Areas Meeting the Healthy Fitness Zone	Number	%	Cum. %	Number	%	Cum. %	Number	%	Cum. %
6 of 6 fitness criteria	124,835	27.1	27.1	142,497	30.9	30.9	134,549	30.1	30.1
5 of 6 fitness criteria	121,124	26.3	53.3	120,883	26.2	57.1	118,683	26.5	56.6
4 of 6 fitness criteria	93,312	20.2	73.5	87,868	19.1	76.2	85,995	19.2	75.8
3 of 6 fitness criteria	63,313	13.7	87.3	57,764	12.5	88.7	54,712	12.2	88.0
2 of 6 fitness criteria	36,926	8.0	95.3	32,083	7.0	95.6	28,145	6.3	94.3
1 of 6 fitness criteria	16,571	3.6	98.8	14,041	3.0	98.7	12,950	2.9	97.2
0 of 6 fitness criteria	5,323	1.2	100.0	6,099	1.3	100.0	12,642	2.8	100.0
Total tested	461,404	100		461,235	100		447,676	100	

APPENDIX B

SUMMARY OF IMPROVEMENTS IN RANGE OF MOTION SEEN IN RESEARCH

Author	Year	*ROM Increase	**Improvement
Bonnar	2004	significant	+9.5 percent
Burke	2001	significant	+25.3 degrees
Cornelius	1992	Greater	
Cornelius	1992	effective	+11.3 percent
Cornelius	1995	effective	
Feland	2004	significant	
Funk	2003	significant	+9.6 percent
Greico	2002	Superior	
Hinton	2007	significant	+19.8 percent
Klein	2002	can improve	
Mitchell	2007	significant	
Osternig	1990	increased	+13 percent
Sady	1982	preferred	+10.6 degrees
Sharman	2006	most effective	
Spernoga	2001	significant	
Walker	2008	very effective	
Weerapong	2004	effective	
Williams	2004	Superior	+9.45 degrees
Worrell	1994	effective	+25.7 percent

*term used to describe ROM in article conclusion.
**statistical improvement in ROM.

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