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A Critical View of Static Stretching and Its Relevance in Physical Education

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Abstract

Stretching before activity has been a customary part of most physical education classes (PE), with static stretching typically the preferred method due to its ease of implementation. Historical and implicit support for its continued use is due in part to the sit-and-reach test and flexibility as one of the components of health-related fitness. This paper examined the use of static stretching in K–12 PE settings by reviewing the effect of flexibility on its related benefits. The results suggested that (a) static stretching has not been shown to reduce injury risk or muscle soreness; (b)some stretching protocols have demonstrated reduced strength and performance; (c) low back pain is not correlated to trunk flexibility; (d) cardiorespiratory fitness, muscular fitness, and body composition have been identified to correlate with future health-related benefits, and flexibility has not. Static stretching reduces activity time in PE and provides little useful health benefits besides flexibility. Physical educators should use dynamic stretching instead.

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At the beginning of a physical education (PE) class, most physical educators include passive stretching. This long-standing scenario is commonly observed in many PE classes, where either the teacher or students direct static stretching as a part of warm-up. Three or more minutes devoted to stretching may not seem like a significant portion of the instructional time, but for the 30-min elementary or middle school PE class, that is at least 10% or more of the valuable instructional time. Does static stretching contribute to health-related fitness benefits? Are static stretching and sit-and-reach test rituals worthwhile in PE? To address these questions, this paper reviewed the current research regarding the role of static stretching and its place in PE.

Flexibility and Stretching

The American College of Sports Medicine (ACSM, 2010) defines flexibility as the ability of a joint to move through its complete range of motion. Stretching durations of 15 s to more than 1 min can be seen in PE settings and research protocols. Rubini, Costa, and Gomes (2007) completed a meta-analysis on the effects of stretching on strength gains and found that most studies used approximately 30-s stretch regimens. Different stretching methods including static, ballistic, proprioceptive neuromuscular facilitation (PNF), and dynamic stretching are employed to increase flexibility. Static stretching is defined as moving a joint to an endpoint and holding that position (Taylor, Dalton, Seaber, & Garrett, 1990). Ballistic stretching involves repetitively bouncing at the end of a joint's range of motion (Shellock & Prentice, 1985). PNF stretching is defined by the use of a partner during stretching and is typically seen as a contract–relax method or a contract–relax–antagonist method (Etnyre & Abraham, 1986). Dynamic stretching, dynamic flexibility, and dynamic warm-ups are often used interchangeably due to having inherent commonalities: the presence of a muscular contraction and movement. Dynamic flexibility refers to the degree with which a joint can be moved as a result of a muscle contraction (Shellock & Prentice, 1985). Therefore, dynamic stretching can be described as actively moving a joint through its range of motion. Dynamic warm-ups are typically referred to in a sport or physical activity setting and typically seek to mimic the movements of the subsequent activity.

Numerous espoused reasons exist for the pervasive role of static stretching in PE, including decreasing the risk of injury, improving athletic performance, reducing risk of low back pain and delayed onset muscle soreness, and improving flexibility via the sit-and-reach test. Before we delve into this contentious topic, let us be clear with several acknowledgements. First, static stretching has been repeatedly shown to improve students' flexibility (Laroche & Connolly, 2006; Medina, Andujar, Garcia, Minarro, & Jordana, 2007; Wallin, Ekblom, Grahn, & Nordenborg, 1985; Williford, East, Smith, & Burry, 1986). In addition, some athletes will require flexibility training to meet the increased range of motion (ROM) demands of their sport, such as diving, gymnastics, and wrestling, to name a few. However, this article solely addresses the pervasive trend of static stretching in K–12 PE with the following questions: (a) What effect does stretching have on injury risk, strength and performance, and muscle soreness? (b) Is low back pain correlated to trunk flexibility (via static stretching measured by the sit-and-reach test)? (c) Do the four health-related fitness components contribute to or predict future health benefits? (d) What is the role of static stretching as part of a quality PE class? These questions were addressed to provide insights into static stretching in PE class and what factors drive this pervasive trend. Furthermore, flexibility testing—sit-and-reach for the purposes of our evaluation—were also examined to discuss its usefulness and tacit influence on PE teachers' use of static stretching.

Effect of Stretching on Injury Prevention, Performance, and Muscle Soreness

The topic of stretching linked to reduced injuries has been extensively researched and has vacillated when examined in different decades. For example, the ACSM position paper (Pollock et al., 1998) suggested that general stretching programs have been shown to reduce the severity and frequency of injuries (Doucette & Goble, 1992; Ekstrand, Gillquist, & Liljedhal, 1983; Hilyer, Brown, Sirles, & Peoples, 1990; Smith, 1994). However, early research at this time was hypothesized to be fraught with concomitant factors that did not adequately isolate the variables studied. Current research has led the ACSM to advise that the relationship between flexibility as measured by static stretching and a reduction of musculoskeletal injury has not been demonstrated in the literature (Kravitz, 2011). This statement is significant considering how influential and respected the ACSM's positions are on exercise and fitness prescriptions. Despite this recent knowledge, stretching has continued to be a central part of most sports teams and PE curricula even though research findings (Knudson, 1999; Murphy, 1991; Small, McNaughton, & Matthews, 2008) have continuously discounted the perceived injury prevention benefits of stretching.

A seminal research study by Pope, Herbert, Kirwan, and Graham (2000) used 1,538 male Army recruits. Two groups, stretching and nonstretching, were examined during 12 weeks of training, with both groups performing active warm-up exercises before physical training. The authors did not find evidence of stretching reducing injuries. It cannot be argued that a number of studies have found statistically significant results when examining stretching and injury prevention, as evidenced previously within the ACSM's position paper (Pollock et al., 1998). However, current meta-analyses have critically looked at the supposed link. One of the earliest meta-analyses was performed by Shrier (1999), who examined 138 clinical and sport science articles related to stretching and injury prevention and found that "stretching before exercise does not reduce the risk of local injury" (p. 221). Thacker, Gilchrist, Stroup, and Kimsey (2004) performed a meta-analysis on the impact of various stretching protocols on sports injury risk and found that stretching was not significantly associated with a reduction in total injuries, Odds Ratio = 0.93, 95% CI [0.78, 1.11], with similar findings seen in subgroup analyses. Herbert and Gabriel (2002) similarly concluded through their meta-analysis that stretching before exercise does not seem to provide a useful reduction in injury risk. One of the most recent meta-analyses examined the efficacy of static stretching as part of a warm-up for the prevention of exercise-related injuries. Small et al. (2008) examined both randomized clinical trials and controlled clinical trials and concluded that there is moderate to strong evidence that regular application of static stretching does not reduce overall injury rates. Some researchers have even argued that preexercise stretching may increase the risk of injury (Brandenburg, 2006; Ingraham, 2003; Shrier, 1999; Weldon & Hill, 2003). This is certainly a more capricious subject.

The relationship between stretching and strength and performance is continually being evaluated through various research designs. One of the earliest studies compared warm-up, massage, and stretching on muscular strength and found no decrease in strength related to stretching (Wiktorsson-Moller, Oberg, & Ekstrand, 1983). Shrier (2004) performed a meta-analysis including

23 articles examining the effects of acute bouts of stretching and found that stretching does not improve force or jump height and was equivocal with regard to running speed and economy. Shrier (2005) concluded that an isolated act of stretching before exercise likely impairs performance in strength and power sports. When exploring the effects of stretching on strength, Rubini et al. (2007) concluded that substantial evidence exists to suggest that strength will decrease following stretching. It appears that for longer durations (30 s to 90 s) or for multiple sets of static stretching, the stretch tolerance allows for increased joint range, yet the viscoelastic characteristics of the muscle remain unchanged (Magnusson, Aagard, Simonsen, & Moller, 1998). Based upon the current research evidence, static stretching clearly does not significantly contribute to strength and performance.

It was postulated that stretching after a heavy bout of exercise can reduce muscle soreness. Delayed onset muscle soreness (DOMS), as its name implies, typically appears 24 hr to 72 hr postactivity. Research by Herbert and Gabriel (2002) evaluated five studies to determine the effects of stretching before and after exercise on muscle soreness and concluded that stretching before or after exercising does not confer protection from DOMS. Stretching to prevent or diminish muscle soreness was also evaluated in subsequent research (Thacker et al., 2004; Weldon & Hill, 2003; Young & Behm, 2002), with no statistically significant findings. In conclusion, the majority of research has indicated that stretching preactivity has been shown to be ineffective in reducing injury rates and DOMS after exercise, and moderate support exists that stretching preactivity may negatively affect certain performance measures.

Low Back Pain and Trunk Flexibility (Measured by the Sit-and-Reach Test)

Decades ago, an association was hypothesized between reduced back flexibility and increased low back pain (Biering-Sorensen, 1984). Furthermore, Golding (1997) surmised that because low back pain is common in the population, keeping the low back flexible is desirable. This theory ushered in flexibility testing, specifically the sit-and-reach test, which was originally designed to measure trunk–hip flexibility. The earliest mention of the test was by DiNucci and Shore (1973), who created eight motor fitness tests after surveying 162 members of the Research Council of the American Association for Health, Physical Education, and Recreation. Thus, the flexibility component that was postulated long ago is still routinely listed as one of the four components of physical fitness. When examining PE settings and flexibility assessment, the most widely used test in schools today is still the sit-and-reach and its many variations such as V sit-and-reach and back saver sit-and-reach.

Current research and several large-scale studies from decades ago that have examined the relationship between low back pain and flexibility do not support a positive association. Battie et al. (1990) used a questionnaire with a large sample size (*N* = 3,020) and found no significant association between sit-and-reach scores, lateral bend measures, and the risk of future back pain. Jackson et al. (1998) evaluated low back pain in adults to identify any relationship between sit-and-reach and sit-up scores on low back pain. They found that the sit-up and sit-and-reach scores were unrelated to the presence of low back pain and were not valid test items for health-related fitness batteries—as a function of preventing low back pain. A more recent study by Grenier, Russell, and McGill (2003) examined the relationships between lumbar flexibility, sit-and-reach test score, and a previous history of low back discomfort in industrial workers. They found that sit-and-reach scores were not related to low back pain discomfort and that the value of sit-and-reach as an indicator of previous back discomfort is questionable. Andersen, Wedderkopp, and Leboeuf-Yde (2006) examined the association between back pain and physical fitness in 17-years-old adolescents (*N* = 9,413). The results indicated no association among aerobic fitness, functional strength, flexibility, or physical activity level after an adjustment for muscular endurance. Additionally, Andersen et al. concluded that "children with high isometric muscle endurance were less likely to report back pain. No other measures of physical fitness or level of self-reported physical activity were linked to back pain reporting" (p. 1740). This research not only lends support to a lack of correlation between sit-and-reach flexibility and low back pain, but also provides support for improving muscular fitness to reduce the incidence of low back pain.

Health-Related Fitness Components and Their Health Benefits

Along with body composition, cardiorespiratory endurance, and muscular strength and endurance, flexibility has long been considered an important part of the components of health-related fitness. Unfortunately, little research is available that answers the following questions: To what extent can flexibility predict health-related fitness and its benefits? What does a better flexibility score mean? Is it associated with health-enhancing benefits? Furthermore, if flexibility is an integral component of health-related fitness, does it correlate with the other components associated with physical fitness? Or can flexibility stand alone with regard to its usefulness?

Body composition is typically measured by body mass index (BMI). BMI is a calculation of a person's weight to height. It is reliable for most subjects and is used to classify individuals into different categories based upon their predisposition of future health problems. A healthier body composition in adolescence is associated with a healthier cardiovascular system and a lower risk of death (Ruiz et al., 2009). In addition, studies have demonstrated that a significant correlation exists between adolescent obesity and adult obesity. Ondrak, McMurray, Bangdiwala, and Harrell (2007) examined 1,824 adolescents aged 8 to 16 and found that percent body fat has a greater influence on cardiovascular disease risk than aerobic power. In addition, the relationship between body fat and total risk score for cardiovascular disease was strongest in the youngest participants (Ondrak et al., 2007).

Cardiorespiratory endurance is measured in numerous ways. The FITNESSGRAM™ uses the PACER and 1-mile run tests, and the President's challenge employs a 1-mile run for time. The correlation between cardiorespiratory endurance and physical fitness is well known to most physical educators. Improved cardiorespiratory fitness allows both the young and the old to be more active, and favorable associations have been found to be related with increased high-density lipoproteins and lower systolic and diastolic blood pressure (Ondrak et al., 2007). Moreover, cardiorespiratory fitness in adolescence is associated with a healthier cardiovascular profile later in life (Ruiz et al., 2009). The appropriateness and usefulness of implementing a cardiorespiratory endurance test would seem apparent to PE teachers.

Muscular strength and endurance are normally referred to as separate components with regard to the components of health-related fitness. For this review, we used muscular strength and endurance as muscular fitness collectively. In PE, the common tests for muscular fitness include curl-ups, push-ups, and pull-ups. Muscular fitness has not been shown to be as strong of a predictor of health-enhancing outcomes when compared to body composition or cardiorespiratory fitness. Malina (2006) examined resistance training in adolescents and found no statistically significant difference in weight, limb circumference, or skinfolds. However, Steene-Johannessen, Andersen, Kolle, and Andersen (2009) identified an inverse relationship with clustered metabolic risk factors, which were independent of cardiorespiratory endurance. Furthermore, Sung, Yu, Chang, Mo, Woo, and Lam (2002) identified short-term effects on blood lipid levels. Finally, studies (Benson, Torode, & Fiatarone Singh, 2008; Sothern et al., 1999) found significant improvements on adipose tissue, waist circumference, and BMI using a strength training program for 8 and 10 weeks, respectively. In summary, the previous components of health-related fitness show that a positive relationship exists among body composition, cardiorespiratory fitness, muscular fitness, and multiple health benefits. That is, a better cardiorespiratory fitness is associated with lower metabolic risk factors.

Increases in flexibility through static stretching, or any type of stretching, can lead to undesirable effects. Muscles that are overstretched can lead to hypermobility, or laxity at the joints. Hayashi, Aizawa, and Mesaki (2010) found that rhythmic gymnasts with a higher general joint laxity were at a greater risk of injury. Furthermore, Ingraham (2003) indicated the increasing ROM beyond function through stretching is not beneficial and can essentially cause injuries and performance decreases. Shrier (1999) provided possible explanations, including (a) decrease in joint stability, making movement at the joint less efficient; (b) increased tissue compliance coupled with a decreased ability for the tendon and muscle to absorb energy; and (c) the ability to put the body into dangerous loading positions due to the increased ROM.

Conversely, a lack of flexibility can impair movement patterns and perhaps lead to tendonitis (Murphy, 1991). Furthermore, Bradley and Portas (2007) found that soccer players with lower ROM at the beginning of the season were more likely to sustain a muscle strain injury. When taken as a whole, both extremes seem to be at risk for injury. Research findings have suggested that individuals with both low and high flexibility appear to have a greater risk of injury than the average individual (Jones et al., 1993; Taimela, Kujala, & Osterman, 1990). In a more recent review of flexibility in dance, Deighan (2005) indicated that the relationship between joint laxity and injury is a U-shaped curve, with very high and very low levels of laxity, increasing the risk of injury. Flexibility would best be expressed through an inverted Bell curve rather than a linear relationship (Figure 1). The very low and very high levels of flexibility come with higher injury risk. Persons that have "average" flexibility tend to mitigate the injury risks from too little or too much flexibility. Therefore, advocating and rewarding K–12 students for increased flexibility scores would seem misguided at best.

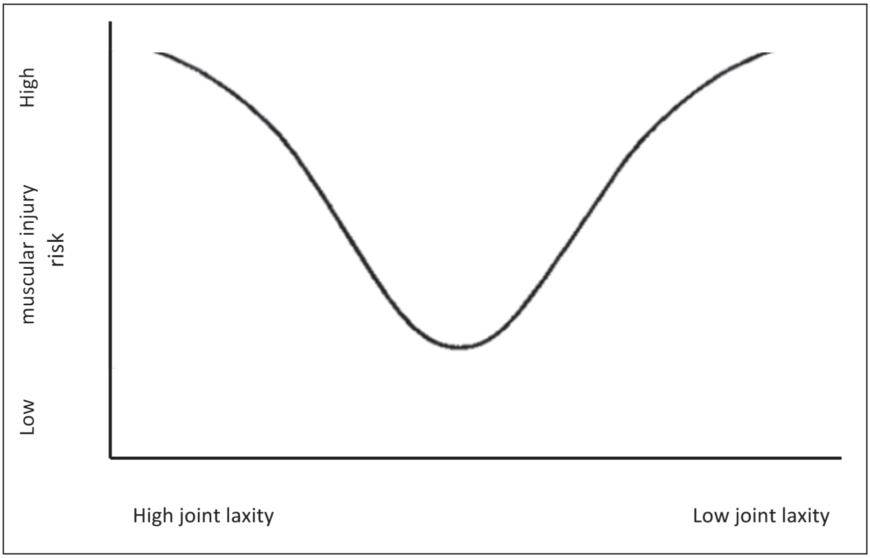

Figure 1. Muscular Injury Risk as a Function of Joint Laxity

Researchers found the correlation coefficients among BMI, cardiorespiratory fitness, and muscular fitness range from moderate to strong (Hands, Larkin, Parker, Straker, & Perry, 2009). However, flexibility seems to be different from the other three components. Hands et al. (2009) found a relationship among physical activity, aerobic fitness, and sit-and-reach scores. Those that performed more physical activity and were in better aerobic shape were "outperformed" by their sedentary counterparts in the sit-and-reach test. The researchers indicated that the greater flexibility scores for the low active and low fit groups may be due to the participants' choice of activity. Pursuits that are more sedentary do not provide the needed muscle recruitment to develop toned muscles, which would provide an advantage when evaluated via the sit-and-reach. Dumith et al. (2010) also found similar results when comparing normal, overweight, and obese boys and girls aged 7 to 15 in eight fitness tests. All fitness test scores were statistically significant ($p < .001$) among groups except for the sit-and-reach test and the medicine ball throw. Fogelholm, Stigman, Huisman, and Metsämuuronen (2008) examined 1,207 overweight and normal weight adolescents on seven fitness tests and found no statistically significant differences between the two groups on the sit-and-reach test. The relationship of BMI to five health-related fitness tests was also used by two different studies (Kim et al., 2005; Tokmakidis, Kasambalis, & Christodoulos, 2006). Tokmakidis et al. (2006) examined fitness in Greek primary children and found a strong relationship with inferior performances in the five fitness assessments and high BMI scores, except in flexibility. In addition, Kim et al. (2005) found no difference in the percentage passing flexibility tests by weight status.

The study findings highlight a problem regarding flexibility being a component of health-related fitness. If flexibility is a component of health-related fitness, but is not correlated to any of the other fitness components, then it should stand on its own merits for its utility. If it does not, then it puts a question mark on the construct validity of health-related fitness: Does the sit-and-reach ability of our students provide fitness benefits? If the answer to this question is no, then what benefit are we affording our PE students by reducing moderate-to-vigorous physical activity in lieu of static stretching protocols linked to a flexibility component that is not associated with any other health or fitness components?

Role of Static Stretching in Physical Education

Physiologically, the warm-up increases the heart rate, blood pressure, and blood flow to the working muscles, thus helping to warm up the muscle and increase metabolic processes to produce faster and more forceful contractions (Safran, Seaber, & Garrett, 1989). Static stretching, or any other type of stretching, is used to increase ROM at the specific joint (Shellock & Prentice, 1985). The common recommendation—if performing static stretching—is to perform a light jog or calisthenics prior to engaging in any type of stretching (Murphy, 1991). As illustrated previously, typical PE classes begin with either static stretching or a warm-up or calisthenics followed by static stretching. This warm-up and stretching ritual is ubiquitous, from television coverage during the pregame of professional sports, to PE classes addressing the flexibility component as part of the four health-related fitness components. However, typical PE programs do not have the seemingly unlimited time that professional athletes, or even recreational athletes, have to prepare for more intense physical activity. An unfortunate trend in school systems is the reduced instructional time. Some students only receive PE 1 day per week. Primary schools typically have 30-min PE classes, with middle and high school classes averaging approximately 45 min to 55 min. This is unfortunate and further highlights the need to use our students' valuable PE time effectively. A passive stretching regimen, such as static stretching, can take away 10% or more of class time. In addition, no evidence exists suggesting that students need extensive flexibility training. We need to use the existing evidence to pedagogically engineer PE classes to produce optimal student learning and wellness (Zhu, 2013).

Plenty of evidence has shown that students desperately need to improve their health-related fitness components of body composition, cardiorespiratory endurance, and muscular fitness that are closely associated with obesity and other health-related issues. All three of these components cannot be easily achieved without maintaining exercises at particular levels of intensity and duration. Using static stretching procedures does not help PE students achieve the goals of health-related fitness other than flexibility. Although using and teaching static stretching protocols is one effective way to improve flexibility, an alternative is available to help improve both flexibility and other health-related fitness components during warm-up.

Dynamic stretching, sometimes called dynamic warm-up, is not a novel idea. The earliest mention of a form of this practice was found in Murphy's 1991 paper "A Critical Look at Static Stretching: Are We Doing Our Patients Harm?" As suggested from the title, Murphy advocated a different way to "stretch" and referred to his concept as dynamic range of motion training. He described dynamic stretching as moving the joints through their normal range of motion, by using the participant's own muscle action. He advocated creating maximal lengthening of the muscle by contracting the agonist muscle, which allows the antagonist muscle to relax and lengthen through reciprocal inhibition. This type of activity serves two purposes. First, it moves the body through a wide ROM, thus maintaining or improving flexibility. Second, it can serve as a way to quickly warm up the body to perform activities that are more vigorous. For example, a kicking unit in a primary setting or a soccer unit in a middle school or high school will require use of most of the muscles in the lower body. Therefore, a dynamic stretching component might have the students performing high knees, performing feet to buttocks, hopping as they move forward with the opposing leg driven forward and up simulating a soccer kick, and jumping off of one or two feet to simulate heading (for the older students). Sport-specific warm-ups can be differentiated according to skill level, experience, and age, with the overall goal to prepare the body for activity that is more intense through dynamic warm-up. This strategy can be included as part of the instant activity widely demonstrated in many quality PE programs where students quickly get moving once they are dressed appropriately for class. By incorporating skill-based dynamic stretching in a warm-up that uses ROM exercises, and by excluding passive activities such as static stretching, we can increase students' activity quotient and hopefully improve skill themes and movement patterns.

Children have more sedentary distractions, fast food accessibility, high fructose corn syrup, and many other "conveniences" that older generations did not have. To combat this in schools, we need to incorporate physical activity into every allotted minute of our PE programs. Dynamic stretching helps provide the needed warming up of the muscles and ROM activity, and from a child's perspective, it is probably more fun than sitting on the floor and trying to touch his or her toes. Although the removal of passive static stretching in the PE setting may seem like a small step, it is nonetheless a step toward providing increased moderate-to-vigorous physical activity in the PE setting in our fight on childhood obesity. From a macro perspective, the authors believe that the state and national standards for K–12 education should consider revisiting the requirements of static stretching testing in schools. Specifically, a meaningful question based on the most current research needs to be addressed: How relevant and useful is it for PE classes to devote instructional time toward passive static stretching protocols seeking to improve ROM of school-aged children? Perhaps, as with other standardized high-stakes testing, teachers have to emphasize the information on which students will be tested, such as static stretching (sit-and-reach) to improve flexibility testing scores in PE. A recent publication from the Institute of Medicine (2012), however, did not recommend a flexibility test for a national youth fitness survey, stating that "no large-scale studies have been specifically designed to assess the relationship between flexibility and health" (p. 159) and that the use of flexibility tests in schools should be for educational purposes.

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