Is Flexibility Associated with Improved Sprint and Jump Performance?

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Abstract
Aim: Many studies have investigated the effect of stretching on sprint and vertical jump performance with contradictory results. However, there are no previous studies investigating if increased flexibility is associated with improved performance. The purpose of this study is to investigate if there is an association of flexibility and sprint time and vertical jump in athletes.

Methods: This is a cross-sectional study of 37 high school track and field athletes that performed flexibility and performance tests. Hamstring flexibility was evaluated using the sit and reach test and the knee extension angle test. Hip flexor flexibility was determined via the Thomas test. The performance measures used were 100-meter sprint time and vertical jump. Regression analysis was performed between each flexibility measure and the two performance measures.

Results: The average knee extension angle was inversely associated with vertical jump height (r= -0.21 R2=0.19; p=0.008). There was no significant association between sit and reach measurement (r= -0.10, R2=0.02; p=0.362) or average Thomas test (r= -0.01, R2=0.00; p=0.950) with vertical jump height. There was no significant association between sit and reach measurement (r=0.10, R2=0.07; p=0.362) or average Thomas test (r=0.05, R2=0.02; p=0.526), or average Thomas test (r=0.05, R2=0.01; p=0.569) with 100-meter sprint time.

Conclusion: In this first study examining flexibility and athletic performance we found no evidence that flexibility is associated with improved sprint and vertical jump performance. Increased hamstring flexibility, measured by knee extension angle, was associated with a decrease in vertical jump height.

INTRODUCTION
Stretching has been accepted as an integral part of athletic training to decrease injury risk and enhance performance without scientific evidence of its effects. Recently, there have been a number of studies published on the effect of stretching, both acute and chronic, on athletic performance [1]. Studies have shown acute pre-performance stretching bouts have an equivocal or negative effect on jump [2,3] and sprint performance [4-6]. However, a few studies have found that chronic stretching programs may have a positive effect on sprint and jump performance [2,7], although there are others that have demonstrated no effect of a chronic stretching program on sprint and jump performance [8,9]. For example, Woostenhulme et al. reported a six week stretching program in basketball players improved flexibility but did not change vertical jump height [10]. Jaramillo et. al, reported dynamic stretching improved sprint speed better than static stretching [11].

If a goal of stretching is to increase flexibility, a logical question is if increased flexibility improves athletic performance. The purpose of this study was to assess whether hamstring and hip flexor flexibility are associated with improved sprint and vertical jump performance. We hypothesize that there will be no association between the flexibility measures and sprint and jump performance.

MATERIALS AND METHODS
Subjects
The Children’s Hospital Los Angeles Institutional Review Board approval was obtained and written informed consent was
obtained from all participants and their parents (if under 18 years of age). Subjects were recruited on a volunteer basis from the student population at a high school in a major metropolitan city. Subjects qualified for the study by being a member of the high school’s track and field team. An athlete was excluded if they had an injury at the time of testing that prevented the athlete from participating in the data collection. Data collection was performed at the track and field facilities on the school’s campus.

Thirty-seven healthy high school track and field athletes volunteered for this study. There were 14 males and 23 females. The mean age was 16.2 years (range 14.5-18.5). The mean height was 167.1 cm (155.0 cm - 181.6 cm) and the mean weight was 61 kg (41.3 kg - 83.1 kg). This data is summarized in Table 1. Following their standard warm-up consisting of approximately 30 minutes of jogging, dynamic stretching and light running, all athletes participated in the following tests.

### Sit and Reach

The athlete was positioned supine on a chair with one lower extremity fully extended in front of them and the other arm extending towards the lateral malleolus. The joint line with one arm extending towards the greater trochanter and the other arm extending towards the lateral malleolus. The angle of hip flexion was recorded. A negative value was used to denote hip extension. The test was repeated to evaluate the other side. The average angle between the two lower extremities was calculated and used for statistical analysis.

### Knee Extension Angle

The athlete was positioned supine on an examination table with both thighs half off the table. The athlete was asked to hold one thigh and pull the knee towards the chest only enough to flatten the low back and sacrum on the table. The angle on the contralateral hip was then measured using a goniometer. The axis of the goniometer was placed on the lateral aspect of the hip joint centered on the greater trochanter, with the stationary arm positioned along the lateral midline of the abdomen and the moveable arm positioned along the lateral midline of the femur. The angle of hip flexion was recorded. A negative value was used to denote hip extension. The test was repeated to evaluate the other side. The average angle between the two lower extremities was calculated and used for statistical analysis.

### Thomas Test

The athlete was positioned supine on an examination table with both thighs half off the table. The athlete was asked to hold one thigh and pull the knee towards the chest only enough to flatten the low back and sacrum on the table. The angle on the contralateral hip was then measured using a goniometer. The axis of the goniometer was placed on the lateral aspect of the hip joint centered on the greater trochanter, with the stationary arm positioned along the lateral midline of the abdomen and the moveable arm positioned along the lateral midline of the femur. The angle of hip flexion was recorded. A negative value was used to denote hip extension. The test was repeated to evaluate the other side. The average angle between the two lower extremities was calculated and used for statistical analysis.

<table>
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<th>Table 1: Subject Characteristics.</th>
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<tr>
<td>14</td>
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<td>Age (years)</td>
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<td>16.2</td>
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<td>Height (cm)</td>
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<td>167.1</td>
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<td>Weight (kg)</td>
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DISCUSSION

Historically, both acute and chronic stretching programs...
Table 2: Average results of the flexibility and performance measures.

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<tr>
<th>Test</th>
<th>Average (Range)</th>
<th>Average (Range) - Males</th>
<th>Average (Range) - Females</th>
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<tr>
<td>Sit and Reach (cm)</td>
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<td>Knee Extension Angle (degrees)</td>
<td>132.5 (115.0 – 161.0)</td>
<td>127.6 (115.0 – 138.0)</td>
<td>135.4 (117.5 – 161.0)</td>
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<td>Thomas Test (degrees)</td>
<td>-2.6 (-11.0 – 5.0)</td>
<td>-2.3 (-9.0 – 5.0)</td>
<td>-2.8 (-11.0 – 3.0)</td>
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<td>100-Meter Sprint (seconds)</td>
<td>14.9 (12.2 – 22.0)</td>
<td>13.5 (12.2 – 16.1)</td>
<td>15.8 (13.6 – 22.0)</td>
</tr>
<tr>
<td>Vertical Jump Height (inches)</td>
<td>18.0 (11.0 – 27.7)</td>
<td>21.7 (16.9 – 27.7)</td>
<td>15.8 (11.0 – 24.6)</td>
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Table 3: Individual data of the flexibility and performance measures.

<table>
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<tr>
<th>Subject</th>
<th>Age</th>
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<th>SR (cm)</th>
<th>KEA avg (deg)</th>
<th>TT avg (deg)</th>
<th>Sprint (sec)</th>
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SR = Sit and Reach; KEA = Knee Extension Angle; TT = Thomas Test; Sprint = 100-Meter Sprint; Jump = Countermovement Jump
have been thought to improve performance and decrease injury
[12,13]. The effects of stretching, both acute and chronic, on
sprint and vertical jump performance have been studied [2,4-
9]. Shrier found in a review of the literature that there was no
benefit of an acute bout of stretching on vertical jump height
[2]. The effect of acute pre-performance stretching on running
speed is inconsistent among the literature: one study showed it
was beneficial [14], another that it was detrimental [6], and two
that it had no significant effect [15,16]. Similarly, various studies
examining the effect of chronic stretching on sprint and jump
perform found both beneficial and equivocal results [2,7-9].

Ultimately, stretching is aimed to improve an athlete’s
flexibility. Despite the popularity of this practice, few studies
have examined the association between an athlete’s flexibility
and athletic performance. Hamstring flexibility has been shown
to decrease with age in soccer players [17].

The 100 meter sprint was one test chosen to measure athletic
performance as sprinting is a common activity in many sports.
Vertical jump height was chosen as a performance measure as it
is commonly used as a field test to determine maximum muscular
power, [18-20] as well as being a common activity in many sports.

There was no significant association between sit and
reach measurement (r=0.05, R²=0.03; p=0.284), average knee
extension angle (r= 0.02, R²=0.01; p=0.526), or average Thomas
test (r = -0.05, R²=0.01; p=0.569) with 100-meter sprint time.
This result is consistent with Evans, who found no significant
relationship between a football player’s flexibility, measured
by sit-and-reach, and their linear speed as measured in the 40-
yard dash [21]. Similarly, Jaramillo et. al, found no significant
association between flexibility, as measured by the sit-and-reach

In this series, the only statistically significant correlation was
that average knee extension angle was inversely associated with
vertical jump height. Stated another way, athletes with the less
flexible hamstrings jumped higher. Although this was statistically
significant, the coefficient of determination (R-squared) was
low (0.19), which indicates that knee extension angle only has
a small role in predicting vertical jump height. Our findings are
consistent with Wilson, et al who reported that calculated musculo
tendinous stiffness was significantly associated with isometric
and concentric performance in a bench press movement [22].

One may speculate that the association of hamstring flexibility
and vertical jump performance may be a function of the force-
length relationship of muscles. Over 100 years ago Blix described
that muscle force is associated with the length of a skeletal muscle
[23-25]. Muscles generate maximum active force at a certain
length, which is determined by its local environment. If a muscle
is longer (stretched) or shorter (absence of any stretch) less force
is generated [26]. We hypothesize that the most subjects with the
most flexible hamstrings may generate less force for the vertical
jump than those with tighter hamstrings due to the force-length
relationship of the muscles.

A possible limitation of our study is the sample size, yet
significant findings were obtained. Another limitation is
potential measurement error. Although standard, clinical grade
goniometers were used and digital stopwatches, there is always
potential error in measurements.

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