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Research Article

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=0.05, 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.

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.

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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, Woolstenhulmeet. 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 100-meter sprint performance and vertical jump height in high school track and field athletes. 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 167.1cm (155.0cm -181.6cm) and the mean weight was 61 kg (41.3kg-83.1kg). 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 in a seated position in front of a Flex-Tester© box (Novel Products, Inc.; Rockton, IL) with the knees fully extended in front of them and the soles of the feet flush with the box. The athlete was instructed to place one hand on top of the other and push the tab on top of the box as far as possible in a slow, controlled movement without flexing the knees. The distance the tab on the box traveled as a result of this motion was recorded in centimeters.

Knee Extension Angle

The athlete was positioned supine on an examination table with the hip and knee of both lower extremities fully extended. While the lower extremity not being tested remained at rest on the table in the starting position, the lower extremity being tested was placed into 90 degrees of flexion at both the hip and knee joints. With the hip remaining flexed at 90 degrees, the knee was passively extended until the examiner felt resistance. This knee flexion angle was measured with a goniometer on the lateral knee joint line with one arm extending towards the greater trochanter and the other arm extending towards the lateral malleolus. The angle recorded was the angle created between the thigh and leg. This protocol was repeated using the other lower extremity. 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 1: Subject Characteristics.

n	37	
Sex	*Male*	*Female*
	14	23
Age (years)	*Mean*	*Range*
	16.2	14.5-18.5
Height (cm)	*Mean*	*Range*
	167.1	155.0-181.6
Weight (kg)	*Mean*	*Range*
	61.0	41.3-83.1

Vertical Jump Height

To measure vertical jump height, the Just Jump system (Probotics, Inc.; Huntsville, AL) was used. The athlete stood on the mat and performed a countermovement jump, landing on the mat. The hands were placed on the hips throughout the jump to reduce any assistance by arm swing. Additionally, the athletes were asked to not "tuck" their legs while in the air, to maintain uniformity in the testing procedure and to minimize false increases in the vertical jump height given that this system calculates jump height based on the seconds the subject is in the air. The jump height was recorded in inches.

100-Meter Sprint

The athletes were asked to complete a 100-meter sprint as fast as possible. The test was performed on the long side of a standard track. Timing was performed with a stopwatch and recorded in seconds.

Statistical Analysis

The data was analyzed using Stata 12 (College Station, TX). Simple regressions were performed first to assess the relationship of each flexibility measure and each of the two performance measures. A simple regression was also done comparing minutes stretched per week with both performance measures. The level of significance was set at $p<0.05$.

RESULTS AND DISCUSSION

The results for the Sit and Reach, Knee Extension Angle, Thomas Test, Vertical Jump Height, and 100-Meter Sprint, are listed in Table 2. Individual results are shown in Table 3.

Flexibility Measures and Vertical Jump Height

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.

Flexibility Measures and 100-Meter Sprint Time

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.

DISCUSSION

Historically, both acute and chronic stretching programs

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Table 2: Average results of the flexibility and performance measures.

Test	Average (Range)	Average (Range) – Males	Average (Range) - Females
Sit and Reach (cm)	31.9 (22.0 – 48.0)	28.6 (22.0 – 48.0)	33.9 (23.5 – 47.0)
Knee Extension Angle (degrees)	132.5 (115.0 – 161.0)	127.6 (115.0 – 138.0)	135.4 (117.5 – 161.0)
Thomas Test (degrees)	-2.6 (-11.0 – 5.0)	-2.3 (-9.0 – 5.0)	-2.8 (-11.0 – 3.0)
100-Meter Sprint (seconds)	14.9 (12.2 – 22.0)	13.5 (12.2 – 16.1)	15.8 (13.6 – 22.0)
Vertical Jump Height (inches)	18.0 (11.0 – 27.7)	21.7 (16.9 – 27.7)	15.8 (11.0 – 24.6)

Table 3: Individual data of the flexibility and performance measures.

Subject	Age	Sex	SR (cm)	KEA avg (deg)	TT avg (deg)	Sprint (sec)	Jump (in)
1	17.6	F	30.0	117.5	-6	14.45	13.7
2	17.1	M	29.0	130.5	-2.5	13.3	19.7
3	15.1	M	27.0	132.5	5	14.3	20.6
4	16.2	M	23.0	122	4.5	12.8	25.0
5	16.4	F	35.0	141	-4	13.6	14.9
6	15.3	F	44.0	132.5	-8.5	13.8	20.1
7	16.3	F	30.0	133	-7	14.8	15.7
8	14.5	F	24.0	135	-2	13.7	18.4
9	16.4	M	29.0	130	3	14.95	11.9
10	15.8	F	32.0	118	-4	12.8	24.9
11	16.6	F	26.0	129.5	0	12.8	23.2
12	17.2	M	37.0	141	0.5	14.8	13.9
13	16.7	F	26.5	122	1	12.2	27.7
14	16.0	F	27.0	115	-2.5	13.7	20.4
15	14.8	F	23.5	133.5	-0.5	14.2	19.4
16	16.2	M	31.0	137.5	3	15.5	13.2
17	18.3	M	39.0	136.5	2.5	15.4	18.3
18	15.6	F	29.0	124.5	-1.5	12.9	20.5
19	15.5	F	32.0	128.5	-5	15.6	17.5
20	16.1	F	31.0	131	0.5	15.0	13.3
21	15.8	F	38.0	144	3	16.3	13.7
22	16.3	M	30.0	131	-6	13.5	17.1
23	15.2	M	42.0	161	1	14.85	16.0
24	15.6	F	24.5	144.5	-10	16.4	18.9
25	15.7	M	30.5	130	-2	15.5	13.5
26	15.3	F	34.5	138	-3.5	12.4	24.7
27	15.4	F	36.0	127	-0.5	18.1	24.6
28	15.7	F	40.0	125.5	-7	22.0	19.9
29	18.5	F	31.5	140.5	-9.5	15.0	14.6
30	16.3	M	39.0	146	-11	14.4	15.2
31	15.7	M	35.0	134.5	-4.5	17.4	13.4
32	17.0	F	31.5	136	0.5	19.4	11.0
33	15.3	F	23.0	135	-5.5	15.0	16.9
34	18.2	F	24.0	128	-3	15.7	14.6
35	15.6	M	47.0	135.5	-1	15.4	16.0
36	15.1	F	48.0	133.5	-6.5	12.9	21.8
37	17.0	M	22.0	120.5	-9	16.1	23.5

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 test, and sprint speed [11].

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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